

Naval Postgraduate School
Monterey, California 93943-5138

NPS-09-02-003



SUMMARY OF RESEARCH 2000



Department of Computer Science

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Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

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Monterey, California

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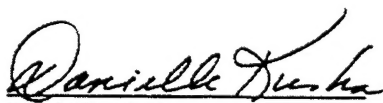
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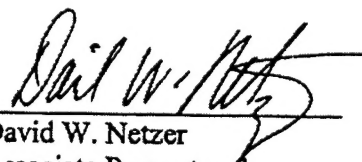
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13. ABSTRACT (Maximum 200 words.)

This report contains project summaries of the research projects in the Department of Computer Science. A list of recent publications is also included, which consists of conference presentations and publications, books, contributions to books, published journal papers, and technical reports. Thesis abstracts of students advised by faculty in the Department are also included.

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Increase the combat effectiveness of the U.S. and allied forces and enhance the security of the U.S.A. through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense related challenges of the future.



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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four graduate schools (School of International Graduate Studies, Graduate School of Operations and Information Sciences, Graduate School of Engineering and Applied Sciences, and Graduate School of Business and Public Policy) and three Research Institutes (The Modeling, Virtual Environments, and Simulation (MOVES) Institute, Institute for Information Superiority and Innovation (I2SI), and Institute for Defense System Engineering and Analysis (IDSEA). This volume contains research summaries for the projects undertaken by faculty in the Department of Computer Science during 2000. The summary also contains thesis abstracts for those students advised by Computer Science faculty during 2000.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the Naval Postgraduate School Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>

Additional published information on the Naval Postgraduate School Research Program can be found in:

- *Compilation of Theses Abstracts:* A quarterly publication containing the abstracts of all unclassified theses by Naval Postgraduate School students.
- *Naval Postgraduate School Research:* A tri-annual (February, June, October) newsletter highlighting Naval Postgraduate School faculty and student research.
- *Summary of Research:* An annual publication containing research summaries for projects undertaken by the faculty of the Naval Postgraduate School.

This publication and those mentioned above can be found on-line at:
<http://web.nps.navy.mil/~code09/publications.html>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing military relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at the Naval Postgraduate School consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- Reimbursable (Sponsored) Program: This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with government laboratories and universities, provides off-campus courses either on-site at the recipient command, by VTC, or web-based, and provides short courses for technology updates.
- Naval Postgraduate School Institutionally Funded Research (NIFR) Program: The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursably sponsored, and (4) to cost-share the support of a strong post-doctoral program.

In 2000, the level of research effort overall at the Naval Postgraduate School was 137 faculty work years and exceeded \$43 million. The reimbursable program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY2000, over 93% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2000 is provided in Figure 1.

INTRODUCTION

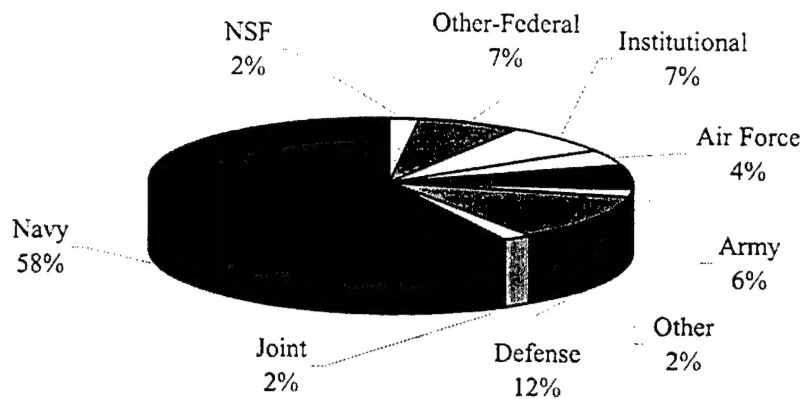


Figure 1. Profile of NPS Research and Sponsored Programs (\$43M)

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2000 is provided in Figure 2.

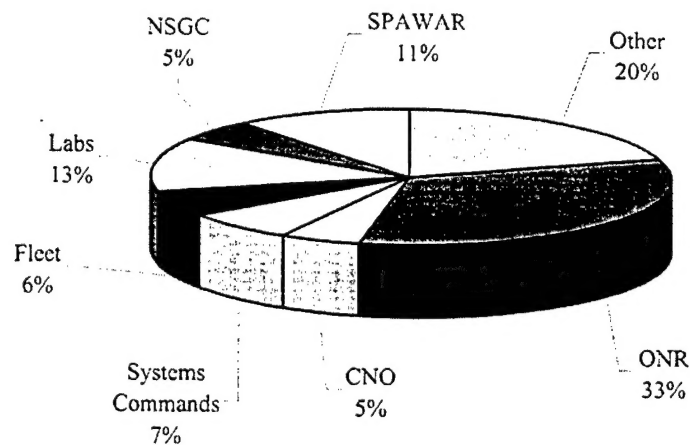


Figure 2. Navy External Sponsors of NPS Research and Sponsored Programs (\$25M)

These are both challenging and exciting times at the Naval Postgraduate School and the research program exists to help ensure that we remain unique in our ability to provide education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

December 2001

**DEPARTMENT OF
COMPUTER SCIENCE**

**DAN BOGER
ACTING CHAIR**

DEPARTMENT SUMMARY

OVERVIEW:

The Department of Computer Science provides graduate training and education in major areas of computer science. Thus, both basic and advanced graduate courses are offered. Course work and research lead to either the degree of Master of Science or Doctor of Philosophy. The requirements to complete either program are rigorous and are comparable to those of other major universities.

CURRICULA SERVED:

- Computer Science
- Software Engineering
- Modeling, Virtual Environments, and Simulation

DEGREES GRANTED:

- Master of Science in Computer Science
- Master of Science in Software Engineering
- Master of Science Modeling, Virtual Environments, and Simulation
- Doctor of Philosophy in Computer Science
- Doctor of Philosophy in Software Engineering

RESEARCH THRUSTS AND FACULTY EXPERTISE:

- Software Engineering:
Professor Luqi, Professor Valdis Berzins, Associate Professor Man-Tak Shing, Military Instructor CDR Deborah Kern, and Military Instructor LCDR Chris Eagle
- Databases:
Associate Professor Thomas Wu and Research Assistant Professor Wolfgang Baer
- Computer Security:
Associate Professor Cynthia Irvine and Lecturer Daniel Warren
- Artificial Intelligence:
Professor Robert McGhee and Associate Professor Neil Rowe
- Computer Graphics:
Professor Michael Zyda, Assistant Professor Rudy Darken, and Lecturer Eric Bachmann
- Networks:
Associate Professor G. M. Lundy and Assistant Professor Geoffrey Xie
- Programming Languages:
Associate Professor Dennis Volpano

RESEARCH FACILITIES:

- Computer Science Academic Laboratory
- Artificial Intelligence and Robotic Laboratory
- Computer Systems and Security Laboratory
- Computer Graphics and Video Laboratory
- Microcomputer Systems Laboratory
- Software Engineering Laboratory
- Visual Database and Interface Laboratory

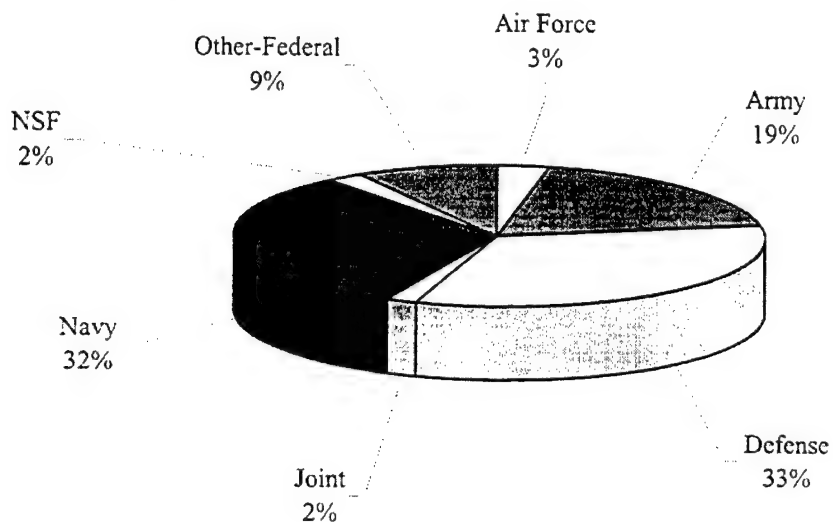
DEPARTMENT SUMMARY

RESEARCH CENTERS:

- Center for Information Security (INFOSEC) Studies and Research (CISR)

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Department of Computer Science is provided below along with the size of the FY2000 externally funded program.



Size of Program: \$3081K

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PROJECT SUMMARIES

SBIR TOPIC N99-34 PHASE II SUPPORT
Wolfgang Baer, Research Assistant Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: Monitor the development of an intrinsic earth surface classification system for application toward a one meter resolution earth surface standard model.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface

KEYWORDS: Simulation, Battlefield Visualization, High Resolution Terrain, Remote Sensing

HIGH RESOLUTION TERRAIN SYSTEMS DEVELOPMENT AND DATA SUPPORT

Wolfgang Baer, Research Assistant Professor
Department of Computer Science
Sponsor: U.S. Army Experimentation Command

OBJECTIVE: The scientific objective of this research is to provide system and software development support for high-resolution database creation, visualization, analysis and integration into operational systems. Tasks include the development of prototype systems and software capable of displaying the high-resolution (1-meter) terrain, and enhancement of after action review capabilities using such products as low cost PC based workstations. Support is also provided for the initialization and construction of sample databases and the porting and testing of existing tools to low cost networked commodity based computer systems.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface

KEYWORDS: Simulation, Battlefield Visualization, High Resolution, Terrain

MICRO TERRAIN TOOLS DEVELOPMENT SUPPORT

Wolfgang Baer Research Assistant Professor
Department of Computer Science
Sponsor: U.S. Army Operational Test Command

OBJECTIVE: Terrain Database Generation Tool Development.

SUMMARY: Provides a tool to build a resolution 1-meter terrain database. The database is initialized using standard elevation models (DTED). It then integrates higher resolution ortho-rectified photo imagery and higher accuracy elevation data from a terrain patch of interest. Finally the tool will recognize terrain feature classes such as trees, bushes, rocks, etc. and perform a 3-D model fit. The tools also provide for interactive editing of the terrain database in order to allow cosmetic and high fidelity corrections.

A Sunview version of the tool was developed for terrain generation at Ft. Hunter Liggett. The tool is now being rewritten for operation in COTS PC hardware under Windows 2000.

The tool will be delivered in FY 2001 in order to support a 64x64 km database construction at Fort Hood, Texas.

PRESENTATION:

Grewe, L.L., Rowe, N., and Baer, W., "AERICOMP: An Aerial Photo Comparison System," SPIE's AeroSense: Signal Processing, Sensor Fusion, and Target Recognition, San Jose, CA, April 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

PROJECT SUMMARIES

KEYWORDS: Terrain Modeling, Pattern Recognition, Geographic Tomography

BATTLEFIELD DATA PROCESSING COURSE DEVELOPMENT

Wolfgang Baer, Research Assistant Professor

Department of Computer Science

Sponsor: Officer of Naval Research

OBJECTIVE: Develop a Course and Research Capability to Support Integration of Virtual Reality and Battlefield Sensing.

SUMMARY: Closing the loop between battlefield sensors and military computer systems in a timely and accurate manner is one of the key requirements for information superiority in 21st century military operations. Future command centers will integrate virtual reality technologies with real-time battlefield sensing systems to support battlefield decisions and data product generation. It is imperative that the future commanders understand the concepts, limits, and capacities of such systems.

The course we plan to develop focuses on the generation of virtual environment databases. Emphasis will be on the techniques, data sources, and active research areas, which produce realistic representations of geographic areas of military interest.

THESIS DIRECTED:

Hunter, J.B. and Grossman, H., "Network Track; Universal Traffic Network," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Sensors, Signal Processing, Communications, Terrain Modeling

TRACER/FCS HIGH RESOLUTION TERRAIN STUDY

Wolfgang Baer, Research Assistant Professor

Department of Computer Science

Sponsor: U.S. Army TRADOC Analysis Command-Monterey

OBJECTIVE: Develop mission scenarios and measure the detectability vs. mission effectiveness of newly proposed scout vehicle designs using the high resolution one meter battlefield terrain simulators.

SUMMARY: TRADOC has been tasked to conduct a TRACER/FSCS Combined Analysis. The objective of this analysis is to determine the most cost effective TRACER/FSCS ground scout system to replace the Bradley Cavalry Fighting Vehicle (CFV) and the High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) used by U.S. Forces, and the Combat Vehicle Reconnaissance Tracked (CVR (T) used by UK Forces.

The purpose of this work is two fold: (1) Define the scenarios, measurements, and software controls and algorithms required to conduct a meaningful analysis of the TRACER/FSCS ground scout system; (2) Develop the support software and execute the analysis if deemed feasible and cost effective.

PUBLICATIONS:

Baer, W., Illingworth, J., Kemple, W., and Mansager, B., "Weapons Design Analysis Using One Meter Terrain Resolution Battlefield Simulators-I," *Proceedings of the 2000 Summer Computer Simulation Conference*, Bill Waite and Abe Nisanci, eds., Vancouver, BC, 16-20 July 2000.

PROJECT SUMMARIES

Illingworth, J., Baer, W., and Mansager, B., "Weapons Design Analysis Using One Meter Terrain Resolution Battlefield Simulators-II," 2000 Fall Simulation Interoperability Workshop, Workshop Paper 00F-SIW-118, 17-22 September 2000, Orlando, FL.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Line-of-Sight, Terrain Modeling, Weapons Design Simulation

SISO INTRINSIC EARTH SURFACE MATERIAL CLASSIFIER SYSTEM PHASE II

Wolfgang Baer, Research Assistant Professor

Department of Computer Science

Sponsor: Office of Naval Research

OBJECTIVE: Build the infrastructure for the construction of such an earth surface material database at one-meter resolution.

SUMMARY: The Simulation Interoperability Standards Organization (SISO) Intrinsic Earth Surface Material Classifier System project will develop the definition of a Standard Surface Material Code (SSMC). To a modeling and simulation program, such a code acts like a pointer to a list of intrinsic earth surface material parameter values that define the physical and radiometric properties of the surface over a broad wavelength range. This information will reside in the Surface Materials Standards list - RESOLVE (Radiometric Earth Surface Observable for Land Visualization Events), which includes materials based on the global abundance of naturally-occurring, man-made, and non-realistic materials, their significance (e.g. importance) to a user community, and availability of spectral data sources to support extraction of intrinsic surface properties. The standard will also include reversible surface rendering and atmospheric propagation equations to allow a traceable connection between measurement and database content. Tools for extracting intrinsic properties of material from remotely required data are basically nonexistent and the suites of surface rendering tools currently available are limited in scope; in other words, they cover an abbreviated wavelength range or include only a limited set of material types. The goal of our effort is to build the infrastructure for the construction of such an earth surface material database at 1meter resolution.

PUBLICATION:

Baer, W., Petroy, S., Shepard, M., Jacobs, E., Cornette, B., and Sunshine, J., "Toward Standard Rendering Equation For Intrinsic Earth Surface Classification," 2000 Spring Simulation Interoperability Workshop, Workshop Paper 00S-SIW-70, 26-31 March 2000, IST, Orlando, FL.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Remote Sensing, Terrain Modeling, BDRF

AUTOMATION SUPPORT FOR SOFTWARE EVOLUTION

Valdis Berzins, Professor

Department of Computer Science

Sponsor: U. S. Army Research Office

OBJECTIVE: To design a system for automating the configuration management needed to keep track of the evolution of a software prototype.

SUMMARY: The objective of the research is to design a system for automating the configuration management needed to keep track of the evolution of a software prototype during a typical application of the evolutionary software prototyping method supported by CAPS. The Computer Aided Prototyping

PROJECT SUMMARIES

System (CAPS) is an integrated software development environment aimed at rapidly prototyping hard real-time embedded software systems, such as missile guidance systems, space shuttle avionics systems, robots, automated factories, telecommunications systems, computer-controlled vehicles, and computer-controlled consumer appliances such as microwave ovens and sewing machines.

We developed an integrated set of formal models and methods to provide decision support and partial automation for software evolution. The mathematical models capture the attributes of and dependencies between versions of software components, as well as the analysis and design activities that produce them. These models support computer-aided planning, cost estimation, automated configuration management, automated team coordination, automated project scheduling, automated project status monitoring and risk assessments. They provide the formalism for algorithms to automatically manage design information, design rationale, human resources, and plans.

PUBLICATIONS:

Berzins, V., Shing, M., Luqi, Saluto, M., and Williams, J., "Architectural Re-Engineering of Janus Using Object Modeling and Rapid Prototyping," *Journal of Design Automation for Embedded Systems*, 5(3/4), August 2000, pp.251-263.

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Berzins, V., "Light Weight Inference for Automation Efficiency," submitted to *Science of Computer Programming*.

Harn, M., Berzins, V., and Luqi, "A Formal Model for Software Evolution," *Proceedings of the 3rd International Conference on Computational Intelligence and Multimedia Applications*, New Delhi, India, 23-26 September 1999.

Harn, M., Berzins, V., and Luqi, "Software Evolution Process via a Relational Hypergraph Model," *Proceedings of the IEEE/IEEEJ/ISAI International Conference on Intelligent Transportation Systems*, Tokyo, Japan, 5-8 October 1999.

Zhang, D. and Luqi, "Approximate Declarative Semantics for Rule Base Anomalies," *Knowledge-Based Systems*, Vol.12, No.7, November 1999, pp.341-353.

Nogueira, J., Luqi, and Berzins, V., "Risk Assessment in Software Requirement Engineering," *Proceedings of the 5th World Conference on Integrated Design & Process Technology*, Dallas, TX, 4-8 June 2000.

Nogueira, J., Jones, C., and Luqi, "Surfing the Edge of Chaos: Applications to Software Engineering," *Proceedings of the 2000 Command and Control Research and Technology Symposium*, Monterey, CA, 26-28 June 2000.

Nogueira, J., Luqi, Berzins, V., and Nada, N., "A Formal Risk Assessment Model for Software Evolution," *Proceedings of 2nd International Workshop on Economics-Driven Software Engineering Research (EDSER-2) of the 22nd International Conference on Software Engineering (ICSE2000)*, Limerick, Ireland, 4-10 June 2000.

Nogueira, J., Luqi and Bhattacharya, S., "A Risk Assessment Model for Software Prototyping Projects," *Proceedings of the 11th IEEE International Workshop on Rapid System Prototyping (RSP2000)*, Paris, France, 21-23 June 2000.

Nada, N., Luqi, Rine, D., and Jaber, K., "Product Line Stakeholder Viewpoint and Validation Models," *Proceedings of the Workshop on Software Product Lines: Economics, Architectures, and Implications of the 22nd International Conference on Software Engineering (ICSE2000)*, Limerick, Ireland, 4-11 June 2000.

PROJECT SUMMARIES

Nada, N., Luqi, Rine, D., and Damiani, E., "A Knowledge-Based System for Software Reuse Technology Practices," *Proceedings of the Third International Workshop on Intelligent Software Engineering (WISE3) of the 22nd International Conference on Software Engineering (ICSE2000)*, Limerick, Ireland, 4-11 June 2000.

Nada, N., Luqi, Rine, D., and Damiani, E., "A Knowledge-Based Adaptive Distance Learning System for Software Reuse Technology," *Proceedings of the Twelfth International Conference on Software Engineering and Knowledge Engineering (SEKE2000)*, Chicago, IL, 6-8 July 2000.

Luqi, Berzins, V., Shing, M., Nada, N., and Eagle, C., "Computer Aided Prototyping System (CAPS) for Heterogeneous Systems Development and Integration," *Proceedings of the 2000 Command and Control Research and Technology Symposium*, Naval Postgraduate School, Monterey, CA, 26-28 June 2000.

Luqi, V. Berzins, M. Shing, R. Riehle and J. Nogueira, "Evolutionary Computer Aided Prototyping System (CAPS)," *Proceedings of the TOOLS-USA 2000*, 30 July-3 August 2000.

Ge, J., Berzins, V., and Luqi, "Computer Aided Prototyping in a Distributed Environment," *Proceedings of the Symposium on Interactive and Collaborative Computing the International Congress on Intelligent Systems and Applications (ISA2000)*, Australia, 12-15 December 2000.

PRESENTATIONS:

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Nada, N., Berzins, V., and Luqi, "Automated Prototyping ToolKit," The 22nd International Conference on Software Engineering (ICSE2000), The 2nd International Symposium on Constructing Software Engineering Tools (COSET2000), Limerick, Ireland, 4-11 June 2000.

Nada, N., Luqi, Rine, D., and Jaber, K., "Using Abstract Adapters for Distributed and Reusable Components," Distributed Networked Computing for a Secure Defense, Washington D.C., 24-25 April 2000.

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Berzins, V., "A Formal Risk Assessment Model for Software Evolution," 2nd International Workshop on Economics-Driven Software Engineering Research (EDSER-2) of the 22nd International Conference on Software Engineering (ICSE2000), Limerick, Ireland, 4-10 June 2000.

Luqi, "A Risk Assessment Model for Software Prototyping Projects," 11th IEEE International Workshop on Rapid System Prototyping (RSP2000), Paris, France, 21-13 June 2000.

Nada, N., "Product Line Stakeholder Viewpoint and Validation Models," Workshop on Software Product Lines: Economics, Architectures, and Implications of the 22nd International Conference on Software Engineering (ICSE2000), Limerick, Ireland, 4-11 June 2000.

PROJECT SUMMARIES

Nada, N., "A Knowledge-Based System for Software Reuse Technology Practices," Third International Workshop on Intelligent Software Engineering (WISE3) of the 22nd International Conference on Software Engineering (ICSE2000), Limerick, Ireland, 4-11 June 2000.

Nada, N., Berzins, V., and Luqi, "Automated Prototyping ToolKit," 22nd International Conference on Software Engineering (ICSE2000) and the 2nd International Symposium on Constructing Software Engineering Tools (COSET2000), Limerick, Ireland, 4-11 June 2000.

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Nada, N., "Using Abstract Adapters for Distributed and Reusable Components," Distributed Networked Computing for a Secure Defense, Washington D.C., 24-25 April 2000.

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THESES DIRECTED:

Harn, M., "Computer-Aided Software Evolution Based on Inferred Dependencies," Ph.D. Dissertation, Naval Postgraduate School, December 1999.

Lee, H., "Integrated Evolution Control System," Masters Thesis, Naval Postgraduate School, December 1999.

Matsuo, E., "Risk Assessment in Incremental Software Development," Masters Thesis, Naval Postgraduate School, December 1999.

Augustine, T., "Naval Architecture Environment: Facilitating JV2010," Masters Thesis, Naval Postgraduate School, December 1999.

Kreeger, G., "Requirements Analysis and Design of a Distributed Architecture for the Computer-Aided Prototyping System (CAPS)," Masters Thesis, Computer Science, Naval Postgraduate School, September 1999.

Nogueira, J., "A Formal Model for Risk Assessment in Software Projects," Ph.D. Dissertation, Naval Postgraduate School, September 2000.

Allen, J. and Tran, T., "Interoperability of COTS Software Components with Legacy Systems in a Distributed Computing Environment," Masters Thesis, Naval Postgraduate School, September 2000.

Gee, K., "An Architectural Framework for Integrating COTS/GOTS/Legacy Systems," Masters Thesis, Naval Postgraduate School, June 2000.

Nguyen, T., "Commercial Off-The-Shelf (Cots)/Legacy Systems Integration Architectural Design and Analysis," Masters Thesis, Naval Postgraduate School, September 2000.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Software Requirements, Evolution, Prototyping, Embedded Systems

XML TECHNOLOGY ASSESSMENT

Valdis Berzins, Professor

Department of Computer Science

Sponsor: Joint C4ISR Battle Center

OBJECTIVE: To evaluate and assess different methods for alleviating data interoperability problems in military systems.

SUMMARY: The JBC needs an assessment of technical issues related to the use of XML to achieve data interoperability in military systems. An XML schema should accommodate controlled change to enable incremental approaches to implementation that add one system at a time. If changes are done according to the least effort for each individual data interchange connection between legacy systems, the XML schema may become bloated with many different coding of the same information, which will eventually become a severe maintenance problem. The NPS Software Engineering Group proposes to evaluate and assess different methods for alleviating this problem.

We have investigated the use of XML for achieving data interoperability between DoD legacy systems from several points of view: methods for integrating XML schemas covering data interchange between pairs of systems, methods for using XML to transfer data between heterogeneous databases, and XML for data interchange between real-time systems. We have assessed the capabilities of commercial tools related to XML and XML interfaces to the commercial database systems used in the systems of interest to JBC. We have also assessed methods for translating between different XML representations of the same real-world data, corresponding to the different views of that data as modeled in different legacy systems.

PUBLICATION:

DaBose, M., "The Joint Technical Architecture Relationships and Implementation in Real Time Hard Time Systems," *Software Engineering Process Group Newsletter*, May 2000.

THESES DIRECTED:

Lyttle, B. and Ehrhardt, T., "Interconnectivity via a Consolidated Type Hierarchy and XML," Masters Thesis, Naval Postgraduate School, December 2000.

Hina, D., "Evaluation of the Extensible Markup Language (XML) as a Means for Establishing Interoperability between Homogeneous Department of Defense (DoD) Databases," Masters Thesis, Naval Postgraduate School, September 2000.

Gee, K., "An Architectural Framework for Integrating COT/GOTS/LEGACY Systems," Masters Thesis, Naval Postgraduate School, June 2000.

Tran, T.M. and Allen, J.O., "Interoperability and Security Support for Heterogeneous COTS/GOTS/Legacy Component-Based Architecture," Masters Thesis, Naval Postgraduate School, June 2000.

Nguyen, T.M., "Commercial-Off-The-Shelf (COTS)/Legacy Systems Integration Architectural Design and Analysis," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Database, Interoperability, XML Schema

PROJECT SUMMARIES

EVALUATION OF COTS ENTERTAINMENT SOFTWARE FOR ARMY RECRUITMENT

Michael Capps, Research Assistant Professor

Department of Computer Science

Sponsor: Office of Economic and Manpower Analysis

OBJECTIVE: COTS videogame software has great potential to aid Army recruiting and training efforts. However, there has to date been little collaboration between the Defense Department and the entertainment industry in this area. While there is significant interest in reproposing COTS software for Army needs, this requires an investigation study into current technology and the ease with which this adaptation can be performed.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Modeling and Simulation

SOFTWARE FRAMEWORK FOR COMPOSABLE AND SECURE VIRTUAL ENVIRONMENTS

Michael Capps, Research Assistant Professor

Department of Computer Science

Sponsor: Secretary of the Air Force

OBJECTIVE: We propose to develop systems architecture to support composable and extensible immersive virtual environments. This framework will allow development of Novel Application in the intelligence domain, both through composition of existing programs and rapid development of new applications. We additionally used this platform to explore new methods for security in virtual world telecollaboration.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Synthetic Environments, Virtual Environments, Modeling and Simulation

DIGITAL IMAGERY AND WIRELESS COMMUNICATIONS FOR LAND-BASED RECONNAISSANCE MISSIONS: A HUMAN FACTORS APPROACH

Rudy Darken, Assistant Professor

**Department of Computer Science and Modeling and Virtual Environments,
and Simulation Academic Group**

Sponsor: Center for Reconnaissance Research

OBJECTIVE: The use of streaming digital video and GPS data via wireless communications is proposed as a method of improving land-based reconnaissance. The ability to gather and disseminate reconnaissance data in its natural form and in a timely, comprehensible fashion is imperative to mission success. This proposal suggests a human factors-based approach whereby a task analysis is used to drive a prototype implementation. This prototype is to be evaluated with the cooperation of MCTSSA for utility and effectiveness. Lastly, methods of coordinating multiple streams of reconnaissance data into coherent tactical picture for the unit commander is needed to adequately capture crucial information from these non-standard form of data.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Technology, Wearable Computing, Wireless Communications, Usability

PROJECT SUMMARIES

MSHN: MANAGEMENT SYSTEM FOR HETEROGENEOUS NETWORKS

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: Research and design effort directed at solving the fundamental problems associated with and creating a distributed metacomputer.

SUMMARY: Phase I of the MSHN Project was completed in 2000. The accomplishments of the project include a peer-to-peer architecture composed of the following components: client library, scheduling advisor, resource requirements database, resource status server, MSHN daemon, and application emulator. The architecture supports the execution of many different client applications, both new and previously unencountered.

Mapping algorithm research supported the MSHN scheduler and resulted in the development of a "toolbox" of mapping techniques from which the scheduler can select the most appropriate algorithm for a given heterogeneous computing and application environment. A unified mapping framework was developed addressed two mapping problems: mapping with advance reservation and data replication, and mapping with resource co-allocation requirements.

MSHN produced a resource model that allows the system to make mapping decisions. Monitoring is needed to ensure that model represents the resources available. Strategies were developed to permit monitoring to be performed at each client. A number of techniques and tools were explored to permit the monitoring and modeling of communications resources.

The research explored the problem of distributed communications in an environment requiring transfers of large quantities of data. A uniform framework for developing communication schedules for collective communication patterns was introduced. The schedules were adapted at run-time, based on network performance information.

Performance metrics were developed so that the success of MSHN as a resource management system could be measured. A multi-dimensional performance measure was developed that included: priorities, task and data versions, deadlines, situational modes, security, and other dependencies.

Security was an integral part of the MSHN project. Multi-domain cryptographically enforced security architecture was developed that provided authentication and confidentiality for MSHN components. The notion of Quality of Security Service was introduced and developed as part of the project.

PUBLICATIONS:

Kim, J. -K., Hensgen, D., Kidd, T., Siegel, H.J., St. John, D., Irvine, C.E., Levin, T., Prasanna, V.K., and Freund, R. F., "A QoS Performance Measure Framework for Distributed Heterogeneous Networks," *Proceedings of EuroMicro-PDP*, Rhodes, Greece, January 2000, pp. 18-27.

Irvine, C.E., and Levin, T., "The Effects of Security Choices and Limits in a Metacomputing Environment," Naval Postgraduate School Technical Report, NPS-CS-00-004, April 2000.

Irvine, C.E., Siegel, H.J., Prasanna, V., Hensgen, D., and Levin, T., "Management System for Heterogeneous Networks Final Report, Volume I: Project Summary and Papers," NPS Technical Report NPS-CS-00-006, April 2000.

THESES DIRECTED:

Schaeffer, B., "Refining a Task-Execution Time Prediction Model for Use in MSHN," Masters Thesis, Naval Postgraduate School, March 2000.

Tsai, P., "Re-Targeting the Graze Performance Debugging Tool for Java Threads and Analyzing the Re-Targeting to Automatically Parallelized (FORTRAN) Code," Masters Thesis, Naval Postgraduate School, March 2000.

PROJECT SUMMARIES

Polk, K., "Transparent Detection of QoS Violations for Continuous Applications," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Heterogeneous, Distributed Computing, Data Staging, Metacomputing

MSHN: QUALITY OF SECURITY SERVICE FRAMEWORK

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The objective of this research is to develop security architecture for management system for heterogeneous networks (MSHN) and, within the context of network quality of service, determine how requirements for security can be integrated into the task scheduling mechanism. The current research addresses: specification of security requirements, determination of possible job resources, costing of possible job resources, and selection of job resources to maximize benefit.

SUMMARY: A method for articulating network security functional requirements, and for measuring their fulfillment has been developed. Using this method, security in a quality of service framework (QoSS) is discussed in terms of variant security mechanisms and dynamic security policies. It was also shown how QoSS can be represented in a network scheduler benefit function.

A model for analyzing the relationship between the security services provided at the various network layers was developed and reflects the choices made by dependent layers as constrained by the limits imposed by underlying layers. In addition, a method for performing security allocation and assignment with respect to security choices made by metacomputer users and applications was presented.

Preliminary security service taxonomy was defined to provide the resource management system with potential resource utilization costs. Based upon this taxonomy, we developed a framework for defining the costs of various network services.

The problem of how users and administrators can easily interact with the wide range of security resources and mechanisms was addressed. A method for translation of a simplified user abstraction of security to detailed underlying mechanisms was formulated.

An approach for representing the level of resources consumed by jobs under the control of a resource management system was developed. This work showed how this measurement of resource usage can be combined with a notion of user preferences to reflect a restrictive resource-usage policy for network management.

PUBLICATIONS:

Spyropoulou, E., Levin, T., and Irvine, C.E., "Calculating Costs for Quality of Security Service," *Proceedings of the 16th Computer Security Applications Conference*, New Orleans, LA, December 2000, pp. 334-343.

Irvine, C.E. and Levin, T., "Quality of Security Service," *Proceedings of the New Security Paradigms Workshop*, September 2000, pp. 91-99.

Irvine, C.E. and Levin, T., "An Argument for Quality of Security Service," *Proceedings of the National Computer Security Conference*, Baltimore, MD, October 2000, p. 519.

Irvine, C.E. and Levin, T., "Toward Quality of Security Service in a Resource Management System Benefit Function," *Proceedings of the 2000 Heterogeneous Computing Workshop*, Cancun, Mexico, May 2000, pp. 18-27.

PROJECT SUMMARIES

Irvine, C.E. and Levin, T., *Introduction to Quality of Security Service*, Naval Postgraduate School Technical Report, NPS-CS-00-005, April 2000.

Spyropoulou, E., Levin, T., and Irvine, C.E., *Quality of Security Service Costing Demonstration for the MSHN Project*, Naval Postgraduate School Technical Report, NPS-CS-00-007, April 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Heterogeneous, Distributed Computing, Data Staging, Metacomputing

SUPPORT FOR NPS CISR INFORMATION ASSURANCE RESEARCH PROGRAM

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsor: Defense Information Systems Agency

OBJECTIVE: This project is to support research in information assurance at the Naval Postgraduate School Center for INFOSEC Studies and Research. The research will include work on high assurance multi-level servers, high assurance network authentication, authentication challenges relating to firewalls and an advanced topics short course.

SUMMARY: Results from this research-included examination of user-friendly interfaces for use in systems enforcing label-based policies. Criteria were established to assess the usability of e-mail clients in a label-based context. Popular commercial-off-the-shelf mail clients were evaluated under these criteria and significant differences in usability were found.

In the area of authentication, a framework for high-speed packet authentication was developed that uses a low-overhead temporal method of updating keys that reduces requirements for time-durability of keys. The method accounts for clock drift and network latency. Sufficiency of the derived conditions to protect data and to ensure data deliverability was demonstrated.

A set of topics and preliminary notes for the short course were developed. The course will be presented in the spring of FY01.

PUBLICATIONS:

Irvine, C.E., "Security: Where Testing Fails," *ITEA Journal*, June 2000, pp. 53-57.

Irvine, C.E., "An Argument for Academic Research in Information Security," *Proceedings of the National Information Systems Security Conference*, Baltimore, MD, October 2000, pp. 710-711.

THESIS DIRECTED:

Everett, T., "Enhancement of Internet Message Access Protocol (IMAP) for User-Friendly Multi-level Mail Management," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Information Assurance)

KEYWORDS: Computer Security, Information System Security, INFOSEC, Information Assurance, Network Security

PROJECT SUMMARIES

NAVY IWD/INFOSEC/IA SUPPORT PLAN FOR NPS CISR

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsors: Chief of Naval Operations (N63) and Naval Postgraduate School

OBJECTIVE: The objective of this research is to provide support for the Naval Postgraduate School Center for INFOSEC Studies and Research (NPS CISR) in an integrated approach to INFOSEC research and education that focuses on important computer and network security problems of DoN and DoD. Thus serving the needs of the warfighter. Information warfare defense and Information Assurance (IA) objectives of the DoN are supported through a cadre of officers who have conducted coursework and research in INFOSEC and IA as well as through the ongoing research results produced by NPS CISR.

SUMMARY: Student research supported by this work included an exploration of a Java-based implementation of the new Advanced Encryption Standard, Rijndael on the iButton, of Dallas Semiconductor. Performance analysis demonstrated that the cost of using the iButton was high for an unoptimized implementation. Among the implementation challenges were the absence of general support for matrix operations, upon which the AES algorithm is dependent.

Several ongoing projects intended to support the emerging DoD public key infrastructure (PKI) were started. These included an examination of the feasibility of the use of the PKI in tactical situations. Another study involves configuration management issues for deployed PKI components. A third research effort is exploring metrics for the service level agreement (SLA) for operational services relating to the PKI that are required for the Navy Marine Corps Internet.

Human factors in the perceived and actual level of security awareness are the topic of another investigation. A survey is being developed which will assess security awareness and then a plan to improve security awareness will be recommended.

Highly trustworthy user interfaces for an open source operating system constituted another area within the scope of this research. The objective was to identify all of the mechanisms within the keyboard interface that represent trap doors in the open source system and to modify the design of the input subsystem so that a trustworthy secure attention key was possible. Additionally, this work resulted in the development of a state representation of the interface that could be used for subsequent design of a trusted path interface.

PUBLICATIONS:

Irvine, C. E., "Security Issues for Automated Information Systems," *Handbook of Public Information Systems*, D. Garson, ed., Marcel Dekker, Inc., New York, NY, pp. 231-245, 2000.

Clark, P., "Supporting Mandatory Access Control in an Educational Environment," *Proceedings of the National Information Systems Security Conference*, October 2000.

THESIS DIRECTED:

Bartram, S., "Supporting a Trusted Path for the Linux Operating System," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Information Assurance)

KEYWORDS: Computer Security, Information System Security, INFOSEC, Information Assurance, Network Security

PROJECT SUMMARIES

HIGH ASSURANCE LABEL PROCESSING MAIL SERVICE

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: This research is to develop a prototype demonstration of a basic label processing mail service on a high assurance trusted base. The demonstration will show how a mail service can separate internal/external and secret/unclassified information with high assurance. It is intended to be an initial component of high assurance network security architecture for office automation that will allow the use of COTS applications and operating systems.

SUMMARY: This work resulted in the development of a requirements specification and high-level design specification for a communications protocol. The requirements specification process used a threat model that included both operational and developmental threats. In addition the specification approach addressed both functional and non-functional security requirements. The requirements specification process was iterative and used the design specification as the next stage of system refinement. Notions that were insufficiently abstract were moved to the design specification, while requirements that could be generalized were moved to the requirements specification. Members of the design group played the role of stakeholders in the design process. To ensure that the system specifications were realistic, gedanken experiments were used as part of the process.

Two trusted server processes were completed and tuned for performance. One was the TCB Extension server, which is intended to provide server-side support for a high assurance protected communications channel between the user and the TCB. This server managed the session database that contained client session attributes such as user identification and session level. The other was a secure session server. This trusted module referenced the session database to assign attributes to application protocol servers that were instantiated on behalf of client systems.

Analysis of the security requirements for a TCB Extension was conducted. A prototype board was selected. It is a plug-in board compatible with the 440BX motherboard of the PC architecture. The plug-in board, which supports an Intel i960 processor, can act either as a PCI bridge or as a secure gateway between the PC and the network. The reference monitor properties of the board were examined and it was concluded that the board can be configured to be both non-by passable and tamper resistant by malicious software. A series of experiments were performed to demonstrate these conclusions. In one, the PCI bridge is shut down by setting the base address and the limit for its buffers to the same value. In the other a NMI, which would provide a Secure Attention Key (SAK) was simulated and forced the shutdown of the bridge. Thus it was demonstrated that a SAK could be associated with the plug-in board.

Low-level object reuse on the client PC was examined and several memory areas that would require purging between sessions with differing security attributes were identified. Techniques to initiate purges from an add-on TCB extension were explored. Overwriting, flushing, and memory latency manipulation were among the techniques identified to remove potentially sensitive information from memory.

PUBLICATION:

Balmer, S.R. and Irvine, C.E., "Analysis of Terminal Server Architectures for Thin Clients in a High Assurance Network," *Proceedings National Information Systems Security Conference*, October 2000, pp. 192-202.

THESES DIRECTED:

Brown, E. "Implementation of an SMTP Server for a High Assurance Multi-level LAN," Masters Thesis, Naval Postgraduate School, September 2000.

Rossetti, R., "A Mail File Administration Tool for a Multi-level High Assurance LAN," Masters Thesis, Naval Postgraduate School, September 2000.

Wilson, J.D., "Trusted Networking in a Multi-level Secure Environment," Masters Thesis, Naval Postgraduate School, June 2000.

PROJECT SUMMARIES

Agacayack, C., "Controlling Object Reuse in Clients Supported by a Trusted Computer Base Extension," Masters Thesis, Naval Postgraduate School, March 2000.

Turan, B., "Client Bootstrap Under Trusted Computing Base Extension Control," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Information Assurance)

KEYWORDS: Multi-level Security, Network Security, Distributed Systems Security, COTS Security

HIGH ASSURANCE DISTRIBUTED MULTI-LEVEL COMPUTING ENVIRONMENT, PHASE II

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: This project is to continue work in support of a high assurance distributed multi-level computing environment, building on recent work accomplished on the Naval Postgraduate School High Assurance Label Processing Mail Service Prototype undertaken during Phase I. Areas of study include applicability to collaborative environments, extension of label processing, trusted path extensions, and supporting policy adaptations.

SUMMARY: A study was made of the impact of using commercial-off-the-shelf (COTS) software in the context of a high assurance environment that supports controlled sharing of information by entities in well defined dominance domains. A set of architectures was identified and for these architectures we showed that, while they are capable of supporting multi-level confidentiality policies, they do not generally support partially ordered integrity policies. The applicability of high assurance architectures for the support of integrity is limited by the integrity of the COTS components.

An Apache-based, security-aware web server was developed for a high assurance platform. It was demonstrated that this web server could provide information at or below the session level of properly authenticated network clients.

As part of the network architectural study, a security requirements document was developed. This document reflected a strategy for security requirements engineering based upon a threat model that incorporated developmental and operational threats. We asserted that because some security requirements cause a change in system state, they can be characterized as functional. The requirements that emerged from the process addressed both functional and non-functional concerns.

PUBLICATIONS:

Irvine, C.E. and Levin, T., "Data Integrity Limitations in Hybrid Security Architectures," Naval Postgraduate School Technical Report, NPS-CS-00-008, December 2000.

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THESIS DIRECTED:

Bersack, E., "Implementation of a HTTP (Web) Server on a High Assurance Multi-level Secure Platform," Masters Thesis, Naval Postgraduate School, December 2000.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Information Assurance)

KEYWORDS: Multi-level Security, Network Security, Distributed Systems Security, COTS Systems

NPS CENTER FOR INFOSEC STUDIES AND RESEARCH

Cynthia E. Irvine, Assistant Professor

Department of Computer Science

Sponsors: National Security Agency

OBJECTIVE: The objective of this research is to provide sustained support for the Naval Postgraduate School Center for Information Systems Security (INFOSEC) Studies and Research in the areas of curriculum development, trusted systems laboratory development, faculty development in INFOSEC and Information Assurance, a visiting professor program, an invited lecture series, academic outreach, and graduate utilization. It provides an integrated approach to INFOSEC research and education that focuses important problems of DoN, DoD, and U.S. government, thus serving the needs for the warfighter and intelligence community.

SUMMARY: Research to develop security enhancements for the Linux operating system continued. A framework to add labels to file system objects and to subjects (active system entities) was completed. Work continued on the creation of a trusted path mechanism for Linux. The specification of the trusted path was completed.

Research collaboration between C. Irvine and G. Xie (NPS Computer Science Department) continued with the method for rapid authentication of IP datagrams in high-speed networks. The technique uses rapid changes to key tables for the authentication algorithm.

The broad NPS CISR effort in the area of computer security education continued and included development or improvement of intermediate and advanced graduate courses in computer security, an invited lecture series on computer security topics, and participation in regional and national computer security education activities.

NPS CISR hosted 12 invited lectures during 2000. All were recorded and archived onto CD ROM, which have been made available to sponsors.

Course materials were extended and updated to reflect changes in technology and advances in the areas of network and computer security.

PUBLICATIONS:

Irvine, C.E. and Levin, T., "Is Electronic Privacy Achievable?" *Proceedings of the IEEE Symposium on Security and Privacy*, Oakland, CA, May 2000, pp. 76-77.

Robin, J.S. and Irvine, C.E., "Analysis of the Intel Pentium's Ability to Support a Secure Virtual Machine Monitor," *Proceedings of the 9th Usenix Security Symposium*, Denver, CO, August 2000, pp. 129-144.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Information Assurance)

KEYWORDS: Computer Security, Information System Security, INFOSEC, Information Assurance, Network Security

PROJECT SUMMARIES

SYSTEM ENGINEERING AND EVOLUTION DECISION SUPPORT

Luqi, Professor

Department of Computer Science

Sponsor: U. S. Army Research Office and Naval Postgraduate School

OBJECTIVE: The objectives of this research is to develop a scientific basis for system engineering automation and decision support, with the long term goals of increasing the quality of service provided complex systems while reducing development risks, costs, and time.

SUMMARY: The goal of our research is to develop an integrated set of formal models and methods for system engineering automation. These results will enable building decision support tools for concurrent engineering. Our research addresses complex modular systems with embedded control software and real-time requirements.

We focused on automation of design activities that appear in an evolutionary approach to system development. Decision support for design synthesis, reuse and evolution is emphasized. This research extended recently developed formal methods in system engineering to construct a cohesive set of formal models. These models are used to create and to connect automated processes for computer aided prototyping, requirements validation, and design synthesis. Mathematical models for implementing a set of automated and integrated engineering automation tools were also developed. Our work combined very-high-level specification abstractions and concepts with: (1) formal real-time models, (2) automated management of system design data and human resources, (3) design transformations, (4) change merging, (5) automated retrieval of reusable system design components, and (6) automated schedule construction. We have created automated methods for: (1) generating real-time control programs, (2) generating simulations of subsystems, and (3) coordinating concurrent work by engineering teams. Our work will ensure design consistency and to alleviate communication difficulties. The significance of our work is to: 1) improve system effectiveness and flexibility, 2) increase engineering productivity, 3) reduce system maintenance costs.

This was achieved by providing a higher level of engineering automation coupled directly with requirements validation facilities. Our work will broaden the scope of engineering decision support to include concurrent whole-system engineering, requirement determination, and system evolution. Automated decision support will ensure system quality by decreasing the human effort required. This, in turn, will minimize the incidence of human error. The trial use of operational system prototypes linked with software simulations of selected subsystems enables users to provide feedback for validation and refinement of system requirements prior to detailed design. Maintenance costs can be minimized by reducing the need to repair requirement errors after system deployment. We provided methods for process and system re-engineering at minimal cost. This was achieved by: (1) regenerating new variations of designs from high-level decisions. (2) combining changes, and (3) propagating the consequences of design modifications. These engineering capabilities will enable the Army to improve and integrate its complex systems with reduced costs. Improved systems can reduce Army manpower needs while strengthening information warfare capabilities.

Specific tasks accomplished in FY00 include (1) the development of a risk assessment model for the evolutionary software process; (2) a detailed survey of the software reuse repositories, (3) the development of models to support reuse in product line approach, and (4) tool enhancements for system engineering and evolution decision support.

PUBLICATIONS:

Berzins, V., Shing, M., Luqi, Saluto, M., and Williams, J., "Architectural Re-Engineering of Janus Using Object Modeling and Rapid Prototyping," *Design Automation for Embedded Systems*, 5(3/4), August 2000, pp. 251-263.

Berzins, V., Shing, M., Luqi, Saluto, M., and Williams, J., "Object-Oriented Modular Architecture for Ground Combat Simulation," *Proceedings of the 2000 Command and Control Research and Technology Symposium*, Naval Postgraduate School, Monterey, CA, 26-28 June 2000.

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Berzins, V., "Static Analysis for Program Generation Templates," *Proceedings of 7th Monterey Workshop: Modeling Software System Structures in a Fast Moving Scenario*, Santa Margherita Ligure, Italy, 13-16 June 2000.

Guo, J. and Luqi, "Reuse and Re-Engineering of Legacy Systems," *Proceedings of the 5th World Conference on Integrated Design and Process Technology*, Dallas, TX, 4-8 June 2000.

Guo, J. and Luqi, "A Survey of Software Reuse Repositories," *Proceedings of the 7th IEEE International Conference and Workshop on the Engineering of Computer Based Systems (IEEE ECBS 2000)*, Edinburgh, Scotland, UK, 6-7 April 2000.

Luqi and Nogueira, J.C., "A Risk Assessment Model for Evolutionary Software Projects," *Proceedings of 7th Monterey Workshop: Modeling Software System Structures in a Fast Moving Scenario*, Santa Margherita Ligure, Italy, 13-16 June 2000.

Luqi, Berzins, V., Shing, M., Riehle, R., and Nogueira, J.C., "Evolutionary Computer Aided Prototyping System (CAPS)," *Proceedings of the TOOLS USA 2000 Conference*, Santa Barbara, CA, 30 July-3 August 2000.

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Nogueira, J.C., Jones, C., and Luqi, "Surfing the Edge of Chaos: Applications to Software Engineering," *Proceedings of the 2000 Command and Control Research and Technology Symposium*, Monterey, CA, 26-28 June 2000.

Nogueira, J.C., Luqi, Berzins, V., and Nada, N., "A Formal Risk Assessment Model for Software Evolution," *Proceedings of the 2nd International Workshop on Economics-Driven Software Engineering Research (EDSER-2)*, Limerick, Ireland, 4-11 June 2000.

Nogueira, J.C., Luqi, and Bhattacharya, S., "A Risk Assessment Model for Software Prototyping Projects," *Proceedings of the 11th IEEE International Workshop on Rapid System Prototyping*, Paris, France, 21-23 June 2000.

Luqi, "System Engineering and Evolution Decision Support - Interim Progress Report (01/01/2000 - 09/30/2000)," Naval Postgraduate School Technical Report, NPS-SW-00-001, Naval Postgraduate School, September 2000.

PRESENTATIONS:

Shing, M., "Object-Oriented Modular Architecture for Ground Combat Simulation," 2000 Command and Control Research and Technology Symposium, Naval Postgraduate School, Monterey, CA, 26-28 June 2000.

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Berzins, V., "Static Analysis for Program Generation Templates," 7th Monterey Workshop: Modeling Software System Structures in a Fast Moving Scenario, Santa Margherita Ligure, Italy, 13-16 June 2000.

Guo, J., "Reuse and Re-engineering of Legacy Systems," 5th World Conference on Integrated Design & Process Technology, Dallas, TX, 4-8 June 2000.

Guo, J., "A Survey of Software Reuse Repositories," 7th IEEE International Conference and Workshop on the Engineering of Computer Based Systems (IEEE ECBS 2000), Edinburgh, Scotland, UK, 6-7 April 2000.

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Nogueira, J.C., "Surfing the Edge of Chaos: Applications to Software Engineering," 2000 Command and Control Research and Technology Symposium, Monterey, CA, 26-28 June 2000.

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Luqi, "A Risk Assessment Model for Software Prototyping Projects," 11th IEEE International Workshop on Rapid System Prototyping, Paris, France, 21-23 June 2000.

THESIS DIRECTED:

Nogueira, J.C., "A Formal Model for Risk Assessment in Software Projects," Ph.D. Dissertation, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: System Engineering, Software Evolution, Decision Support, Concurrent Engineering

COMPUTER-AIDED ENGINEERING OF HETEROGENEOUS SYSTEMS

Luqi, Professor

Department of Computer Science

Sponsor: Defense Advanced Research Projects Agency and Naval Postgraduate School

OBJECTIVE: To develop improved methods for engineering and constructing heterogeneous systems and environments.

SUMMARY: This project seeks improved methods to: speed up design and construction, support integration and evolutionary expansion, evaluated and improve performance, and demonstrate

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improvements via a case study. We tackled the problem using prototyping and a "wrapper and glue" technology for the engineering and integration of heterogeneous systems. Our approach is based on a distributed architecture where components collaborate via message passing over heterogeneous networks. It uses a generic interface that allows system designers to specify communication and operating requirements between components as parameters, based on properties of COTS/GOTS components. A separate parameterized model of network characteristics constrains the concrete "glue" software generated for each node. The model enables partial specification of requirements by the system designers, and allows them to explore design alternatives and determine missing parameters via rapid prototyping.

The cornerstone of our approach is automatic generation of wrapper and glue software based on designer specifications. This software bridges interoperability gaps between individual COTS/GOTS components. Wrapper software provides a common message-passing interface for components that frees developers from the error prone tasks of implementing interface and data conversion for individual components. The glue software schedules time-constrained actions and carries out the actual communication between components.

Specific tasks accomplished in FY00 include (1) the design of an interface wrapper model that allows developers to treat distributed objects as local objects, (2) the development of a tool to generate Java interface wrapper from a specification written in the high-level Prototype System Description Language (PSDL), (3) the design of a distributed heterogeneous environment to automate the process of integration distributed systems, (4) a case study involving the development of a "wrapper and glue" solution for integrating/extending COTS/GOTS/legacy components of the Naval Integrated Tactical Environmental System I (NITES I), and (5) the design of high-level net models for fault detection in multistage interconnected networks.

PUBLICATIONS:

Ge, J., Berzins, V., and Luqi, "Computer Aided Prototyping in a Distributed Environment," *Proceedings of the International Congress on Intelligent Systems and Applications (ISA2000)*, to appear in *Proceedings of the Symposium on Interactive and Collaborative Computing*, Australia, 12-15 December 2000.

Cheng, N., Berzins, V., Luqi, and Bhattacharya, S., "Automated Generation of Wrappers for Interoperability," *Proceedings of the 2000 Command and Control Research and Technology Symposium*, Monterey, CA, 26-28 June 2000.

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PRESENTATIONS:

Bhattacharya, S., "Automated Generation of Wrappers for Interoperability," 2000 Command and Control Research and Technology Symposium, Monterey, CA, 26-28 June 2000.

Shing, M., "Computer Aided Prototyping System (CAPS) for Heterogeneous Systems Development and Integration," 2000 Command and Control Research and Technology Symposium, Monterey, CA, 26-28 June 2000.

Berzins, V., "Prototyping Tool-Kit (APT)," 2nd International Symposium on Constructing Software Engineering Tools (CoSET 2000), ICSE 2000, Limerick, Ireland, 4-11 June 2000.

PROJECT SUMMARIES

THESES DIRECTED:

Allen, J. and Tran, T., "Interoperability of COTS Software Components with Legacy Systems in a Distributed Computing Environment," Masters Thesis, Naval Postgraduate School, September 2000.

Franco, R., "Second Generation Ultra High Frequency (UHF) Satellite Protocol," Masters Thesis, Naval Postgraduate School, June 2000.

Gee, K., "An Architectural Framework for Integrating COTS/GOTS/Legacy Systems," Masters Thesis, Naval Postgraduate School, June 2000.

Nguyen, T., "Commercial-Off-The-Shelf (COTS)/Legacy Systems Integration Architectural Design and Analysis," Masters Thesis, Naval Postgraduate School, September 2000.

Cheng, N., "Automated Generation of Wrappers for Interoperability," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: System Engineering, Software, Decision Support, Heterogeneous Systems

ENGINEERING AUTOMATION FOR RELIABLE SOFTWARE

Luqi, Professor

Department of Computer Science

Sponsor: U.S. Army Research Office

OBJECTIVE: To develop technology for reliable software development through the automatic generation of glue and wrappers based on designer's specifications.

SUMMARY: This project addresses the problem of how to produce reliable software that is also flexible and cost effective for the DoD distributed software domain. Current and future DoD software systems fall into two categories: information systems and warfighter systems. Both kinds of systems can be distributed, heterogeneous and network-based, consisting of a set of components running on different platforms and working together via multiple communication links and protocols.

We focused on "wrap and glue" technology based on a domain specific distributed prototype model. Glue and wrappers consists of software that bridges the interoperability gap between individual COTS/GOTS components. The key to making the proposed approach reliable, flexible, and cost-effective is the automatic generation of glue and wrappers based on a designer's specification. The proposed "wrap and glue" approach allows system designers to concentrate on the difficult interoperability problems and defines solutions in terms of deeper and more difficult interoperability issues, while freeing designers from implementation details. The objective of our research is to develop an integrated set of formal models and methods for systems engineering automation. These results will enable building decision support tools for concurrent engineering. Our research addresses complex modular systems with embedded control software and real-time requirements.

Our long-term goals are to construct an integrated set of software tools that can improve software quality and flexibility by automating a significant part of the process and providing substantial decision support for the aspects that cannot be automated. The resulting development environment should be adaptable to enable (1) maintaining integrated support in the presence of business process improvement, (2) incorporation of future improvements in engineering automation methods, and (3) specialization to particular problem domains.

Specific tasks accomplished in FY00 include (1) the design of an interface wrapper model that allows developers to treat distributed objects as local objects, (2) the development of a tool to generate Java interface wrappers from a specification written in the high-level Prototype System Description Language (PSDL), (3) the design of a distributed heterogeneous environment to automate the process of integration

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distributed systems, (4) a case study involving the development of a "wrapper and glue" solution for integrating/extending COTS/GOTS/legacy components of the Naval Integrated Tactical Environmental System I (NITES I), (5) the design of high-level net models for fault detection in multi-stage interconnected networks, (6) tools for assertion checking, dynamic analysis and testing of programs, (7) application of machine learning algorithms in software development, and (8) reliability modeling for safety critical software.

PUBLICATIONS:

Auguston, M., "Assertion Checker for the C Programming Language Based on Computations Over Event Traces," *Proceedings of the Fourth International Workshop on Algorithmic and Automatic Debugging, AADBUG'2000*, Munich, Germany, 28-30 August 2000.

Auguston, M., "Tools for Program Dynamic Analysis, Testing, and Debugging Based on Event Grammar," *Proceedings of the 12th International Conference on Software Engineering and Knowledge Engineering*, Chicago, IL, 6-8 July 2000, pp.159-166.

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Pramanik, S., Choudhury, S., Chaki, N., and Bhattacharya, S., "Conceptual Level Graph Theoretic Design and Development of Complex Information System," *Proceedings of the IEEE International Conference on Information Technology: Coding and Computing (ITCC'00)*, Las Vegas, NV, 27-29 March 2000.

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Auguston, M., "Tools for Program Dynamic Analysis, Testing, and Debugging Based on Event Grammars," *12th International Conference on Software Engineering and Knowledge Engineering*, Chicago, IL, 6-8 July 2000.

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Schneidewind, N., "The Ruthless Pursuit of the Truth about COTS," North Atlantic Treaty Organization, Commercial Off-the-Shelf Products in Defense Applications, Brussels, Belgium, 3-5 April 2000.

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DoD KEY TECHNOLOGY AREAS: Computing and Software

PROJECT SUMMARIES

KEYWORDS: Engineering Automation, Reliability, Glue and Wrapper Technology, Computer-Aided Decision Support

IMPROVED SOFTWARE TECHNOLOGY FOR THE NEXT GENERATION AIRCRAFT CARRIER

Luqi, Professor

Department of Computer Science

Sponsor: Naval Sea Systems Command

OBJECTIVE: To improve software technology in areas of concern to NAVSEA and to apply the results to software issues arising in the future aircraft carriers such as CVX.

SUMMARY: This project seeks to assess the potential for improved Naval damage control operations with fewer personnel enabled by improved communications and decision support technology.

An evaluation of current video tele-conferencing (VTC) technology is complete. The determination of VTC's role and the added value to damage control on CVX is underway and will require some exploration of the TELETECNET training system planned for installation in CVN-75 this fiscal year to consider the as-built configuration, limiting factors and training applicability of VTC to carriers.

Evaluation of barcode technology has reached the product identification stage and for lack of materials, may not be adequately considered in this study. A review of the Smart Ship program has been partially completed. Literature reviews and interviews with crew and design personnel have provided a wealth of information. Migration of some Smart Ship technologies into CVX is expected. Some technologies added to Smart Ship have been in place on carriers for several years, including Hydra radio systems. This technology group and the subsequent reductions in manpower achieved suggest that many of the same lessons will be of great value to CVX. A visit to USS YORKTOWN or USS THOMAS S. GATES to examine the 61 technology items in play would benefit this study.

Wireless LAN technology has been studied and evaluated at the present state of the art. Vigorous product development activity in the wireless community suggests that this technology may yield acceptable advancements that will improve the reliability to support shipboard use for damage control. Live onboard testing is vital to the proof of this concept.

Evaluation of an expert system using a simple inference engine has been completed and indicates this outstanding technology should be organic to the damage control communication system. Further testing and development is needed. More robust applications and prototypes are needed to explore beyond the simple demonstration version. Frank Steinbach made a site visit to the CVX Project Office in Crystal City to discuss the tenets of his M.S. thesis; future career plans with regard to CVX and to gain familiarity with the facility there. In the process of the visit, contact was established with Smart Ship personnel PNC John Bealmear (USN Ret) and Ray O'Toole to obtain firsthand accounts of the Smart Ship learning process and to discuss possible avenues of exploration for use for future CVX use.

A small wireless LAN has been constructed to evaluate the viability of signals between computers utilizing COTS hardware and software to gain a working knowledge of the limitations and capabilities of current technology. The most striking weakness in Wireless LAN technology found is the low propagation of signals when mobile units go beyond the line of sight. However, current "leaky cable" techniques employed in internal communications aboard ship may help to mitigate that weakness and support mobile Repair Lockers.

We have performed live set up and testing on three forms of video tele-conferencing to support tele-training for CVX damage control requirements. One form (CNET's Electronic Schoolhouse) of this training is currently in use aboard several fleet units but requires great bandwidth and dedicated facilities. We have set up and operated the NPS distance learning system to ascertain the capabilities of this technology and current protocol standards. Two other forms, "Video on Demand" (VOD) and desktop tele-conferencing, allow users on general computer assets throughout a ship to participate in training without leaving their own work area. Our test of Precept Corporation's "IPTV" demonstrated that Damage Control training could be conducted through desktop computers throughout a ship via the LAN without the requirement to "Stack" bandwidth for each user. This bodes well for the ability to accomplish multiple

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channels or topics of study at the same time. Several student theses have been reviewed to develop a fuller understanding of Video Technology.

We have constructed a small model of an expert system to demonstrate the ability to program a logical sequence of routines into a simple program on a PC. This technology, if extended, will allow Damage Control Locker Leaders and the Damage Control Assistant to evaluate him/herself in a training situation or to sanity check decisions in a hot environment when lives are at risk while deciding on actions to combat fires, flooding and contamination. This technology is not yet being used to our knowledge but was explored here at NPS in the 1980's when GUI interfaces and rapid prototyping CASE tools were not available. Our contention is that this technology has matured to the point of deserving another hard look. We have acquired a copy of a 1996 study conducted by David Tate at the Naval Research Labs. Tate concludes that decision aids based on inference engines are vital to the effective control of manpower and resources in a tactical damage control situation. We have put up a small web page of technology sources that have contributed to the knowledge collected thus far in our research.

PUBLICATION:

CIDE Supporting Technology and Infrastructure, Final Report.

THESIS DIRECTED:

Williamson, C., "A Sharp Evolution: Development of the Sierra Hotel Aviation Reporting Program from the Deck Plates," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control and Communications

KEYWORDS: Interoperability, C4ISR, Combat Systems, CVX

COMPUTER SUPPORT FOR POLICY

James Bret Michael, Associate Professor

Department of Computer Science

Sponsor: Naval Postgraduate School Research Initiation Program

OBJECTIVE: To explore both the architecture for and components of a computer-based intelligent assistant, known as a policy workbench, for partially automating the generation of policy-governed systems.

SUMMARY: A policy workbench is an integrated suite of computer-based tools for representing policy, reasoning about policy, maintaining policy, and embedding policy as procedures (i.e., computer interpretable or executable code) in information systems. A policy is a statement of a goal, doctrine, or rule of an organization. The workbench serves as an intelligent assistant for developing and maintaining policy-governed systems; the workbench assists users and developers of such systems to identify and resolve gaps in policy before high-level requirements and other system artifacts are derived from the policy base. The policy workbench is also intended for use with legacy systems, in addition to constructing composite systems (e.g., systems supporting coalition forces) from extant systems.

We explored the technical feasibility of implementing three of the components of the policy workbench, one of these being an automatic test-case generator. The second component automatically translates natural language statements of policy into a common information model from which computer-based tools can extract policy objects and relationships to generate tool-specific computational representations of policy for further processing. The third component, an integrated policy compiler and tester, were developed and experiments were conducted to determine to what extent policy regarding network management, specified in the Path-based network Policy Language (PPL), could be tested for logical consistency.

In addition to PPL, we explored to what extent the Reference Model for Open-Distributed Processing (RM-ODP) can be used to model policy for distributed systems. We found that identifying inconsistency in policy regarding interoperability of the subsystems of the Ballistic Missile Defense (BMD) system

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necessitated the use of multiple viewpoints. Further, we found that firm conclusions about the existence of gaps in the policy base must be deferred until the high-level viewpoints are refined.

We also investigated the potential uses of the workbench to define, measure, specify, and compute trust in the context of distributed systems. We developed a modeling framework for specifying discretionary and mandatory policy about what types of trust-relationships can be created, modified, and destroyed between members of an organization, within sub-organizations, and across organizational boundaries. We investigated how the framework could be used to support the development of both the architecture and requirements for the US DoD's information infrastructure (DII), in addition to local infrastructures (e.g., infrastructures for carrier battle groups and the Navy/Marine Corps Intranet).

PUBLICATION:

Gaines, L.T. and Michael, J.B., "Trust Management in OLAP Tools," *Proceedings of the IFIP WG11.3 Working Conference on Database Security*, Schoorl, The Netherlands, 21-23 August 2000.

THESES DIRECTED:

Gaines, L.T., "Trust and its Ramifications for the DoD Public Key Infrastructure," Masters Thesis, Naval Postgraduate School, September 2000.

Smith, S.A., "The Application of a Viewpoints Framework in the Development of C4I Systems," Masters Thesis, Naval Postgraduate School, June 2000.

Stone, G.N., "A Path-Based Network Policy Language," Ph.D. Dissertation, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Policy, Intelligent Assistant, Distributed Systems, Trust

COGNITIVE MODELING FOR TRAINING

Barry Peterson, Research Assistant

Rudy Darken, Assistant Professor

Department of Computer Science

Sponsor: Naval Air Warfare Center-Training Systems Division

OBJECTIVE: The virtual environments for training technology (VETT) program and the Modeling, Virtual Environments and Simulation Academic Group will collaborate to identify a new approach to the human cognitive modeling process that will support our common research objectives and the training of individuals in virtual environments.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Cognitive Modeling, Virtual Environments, Training

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AUTOMATIC UPDATING OF TERRAIN DATABASES FROM SATELLITE IMAGERY

Neil C. Rowe, Associate Professor

Department of Computer Science

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: We will develop a prototype system to update terrain databases with new features observed in aerial photographs using image differencing.

SUMMARY: In 2000 the first phase of the project was concluded by preparing a journal paper that was accepted in December. The main product is a program that takes two crudely registered aerial photographs, finds the exact registration using line segments, calculates the line segments that do not match, and displays them overlaid on the original images. Efficiency improvements made in January now allow the program to provide results in 8 minutes for 256 by 256 image pairs where it previously took 90 minutes.

PUBLICATIONS:

Rowe, N.C. and Alexander, R.S., "Finding Optimal-Path Maps for Path Planning Across Weighted Regions," *International Journal of Robotics Research*, 2 February 2000, pp. 83-95.

Rowe, N.C., Grewe, L., and Baer, W., "A Digital Library of Aerial Photographs Supporting Change Analysis," Poster and presentation at ACM Digital Libraries 2000, San Antonio, TX, June 2000.

PRESENTATIONS:

Hunter, G.K. and Rowe, N.C., "Software Designs for a Fault-Tolerant Communications Satellite," Command and Control Research and Technology Symposium, Monterey, CA, June 2000.

Grewe, L., Rowe, N., and Baer, W., "AERICOMP: An Aerial Photo Comparison System," SPIE Signal Processing, Sensor Fusion, and Target Recognition IX Conference, June 2000.

THESES DIRECTED:

Herman, J., "Target Identification Algorithm for the AN/AAS-44V Forward-Looking Infrared (FLIR)," Masters Thesis, Naval Postgraduate School, June 2000.

Lisowski, M., "Development of a Target Recognition System Using Formal and Semiformal Methods," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Images, Captions, Digital Libraries, Information Filtering, Content Analysis

AN OBJECT-ORIENTED DISTRIBUTED ARCHITECTURE FOR THE CAMPEX SOFTWARE

Man-Tak Shing, Associate Professor

Department of Computer Science

Sponsor: U. S. Army TRADOC Analysis Command

OBJECTIVE: To develop a prototype of an object-oriented distributed architecture for the CAMPEX software.

SUMMARY: The U.S. Air War College uses a set of stand alone war-gaming software, called the Campaign Planning Exercise (CAMPEX), to teach and test its students' understanding of strategy, leadership, international security, National Security Decision Memoranda (NSDM), General Purpose (GP) forces, unified commands, and joint fundamentals in the area of the Air Campaign Planning and the

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Ground Forces Deployment. The CAMPEX software was written in the Basic programming language. Its life cycle started in 1986 and the last version was released in 1994. There is a need to modernize CAMPEX into a Web-based application to take advantage of modern Personal Computers and the World Wide Web. The research conducted in this project succeeded in re-engineering CAMPEX into a web-based platform independent system executable on any networked computer. The research effort produced a set of requirements and an object-oriented design for the enhanced Web-based simulation. The correctness of requirements has been validated via a prototype developed using ACCESS 2000. The new design will be the basis for reengineering the other war game planning software for the Air War College.

PUBLICATION:

Shing, M., Jackson, L., and Chalakatevakis, A., "Architectural Design and Prototyping of a Web-Based War Game Simulation For Campaign Planning Exercises," to appear in the *Proceedings of the 13th Annual Software Engineering Conference*, Salt Lake City, UT, 29 April-4 May 2001.

PRESENTATION:

Shing, M., Jackson, L., and Chalakatevakis, A., "Architectural Design and Prototyping of a Web-Based War Game Simulation For Campaign Planning Exercises," 13th Annual Software Engineering Conference, Salt Lake City, UT, 29 April-4 May 2001.

THESIS DIRECTED:

Chalakatevakis, A., "Architectural Design and Prototyping of a Web-Based War Game Simulation for Campaign Planning Exercises," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Modeling and Simulation

KEYWORDS: Battlespace Environments, Distributed Components Architecture, Object-Oriented Design, Modeling and Simulation.

TYPE SYSTEMS FOR SECURE REMOTE EVALUATION

Dennis Volpano, Associate Professor

Department of Computer Science

Sponsor: National Science Foundation

OBJECTIVE: This is a joint project with Geoffrey Smith at the Florida International University (FIU). The work is part of a continuing project aimed at investigating the role of programming language design and type systems in ensuring the privacy of data in programs. The long-term objective is to identify how languages should be designed in order to be able to prove confinement properties about programs expressed in them. This is the final year of the project.

SUMMARY: In previous years of the project we developed various flavors of Noninterference to capture confinement in different kinds of programming languages. We started with a simple imperative, deterministic language, then looked at a nondeterministic one, and finally a probabilistic one. Confinement is captured by three different Noninterference properties, respectively, NI, Possibilistic NI, and Probabilistic NI. In the final year of the project, we formally characterized the difference between safety properties and confinement properties.

Each however is too strong to allow practical primitives. For example, in password-based authentication, anyone can enter a password and find out whether it is correct. This would be disallowed in any system satisfying NI. To justify a system of this kind, we turned to computational complexity. Investigation continued into probabilistic timing channels and techniques for eliminating them in

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concurrent programs. Secrecy was also contrasted formally with safety properties. It was shown that secrecy relates the traces of a program's execution whereas safety does not.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Programming Language Design

BASIC RESEARCH IN INFORMATION PRIVACY

Dennis Volpano, Associate Professor

Department of Computer Science

Sponsor: National Science Foundation and Naval Postgraduate School

OBJECTIVE: This is a joint project with Geoffrey Smith at the Florida International University (FIU). The work is part of a continuing project aimed at investigating new techniques for proving privacy in systems that downgrade information, for instance, through use of cryptography. New relative notions of secrecy are needed that relate the complexity of leaking secrets in systems to that of breaking cryptographic primitives. Simple examples include password systems that store passwords as images under a one-way function.

SUMMARY: In our previous work, it was proven that leaking a secret S in a deterministic program is as hard as deducing S using only match queries of the form "Does $S = Y$, for a given string Y ?" It can be proved that there is no polynomial time algorithm for deducing a k -bit integer secret S , for all k , if the algorithm is limited to accessing S via these queries.

And, further, no polynomial time algorithm can do it with non-negligible probability if secrets are uniformly distributed and of sufficient size.

Next we considered a one-way hash function H that is characterized by collision resistance. Given $H(z)$, find an x such that $H(x) = H(z)$. Hash functions are not allowed in any system that satisfies NI. Sets of conditions were given under which a one-way hash function can be used safely in programs. It was proved that the existence of an efficient

Deterministic algorithm that meets the conditions and deduces the value of a high input variable v , given $H(v)$, implies there is an efficient probabilistic algorithm for inverting H .

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Programming Languages, Security, Privacy

NETWORK MANAGEMENT SYSTEMS FOR INTEGRATED SERVICES, SAAM

Geoffrey G. Xie, Assistant Professor

Department of Computer Science

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: We are developing a novel server and agent based active management system for the next generation Internet.

SUMMARY: We made progress in the following areas:

(1) Self-repairing Signaling Channels: A Key requirement for SAAM is the ability to reconfigure the signaling channels automatically and in near real time to accommodate changes in network topology. We developed a pro-active approach that refreshes SAAM signaling channels over short time intervals in anticipation of topological changes. The overhead of the resulting protocol is very manageable. On average, each router needs to process two control messages in each refresh cycle. The protocol also provides a means for each router to periodically report its link state information to the server without imposing additional processing overhead on the intermediate routers.

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(2) Intelligent Resource Manager: We focused on optimality rather than complexity in designing the resource manager to run on a SAAM server. The resulting system supports all service classes defined by major Internet service models (Integrated Services, Differentiated Services, and Multi-Protocol Label Switching) in a cohesive manner. It maintains a comprehensive path information base to aid QoS routing and rerouting and optimizes the utilization of network resources via adaptive routing and dynamic link provisioning between service classes.

(3) Server Fault Tolerance: We investigated how to make SAAM services tolerant of server failures. There are two types of server failures. Most are transient and recoverable like component failures. The others are catastrophic failures, not recoverable in a short time. For the first type, we examined current commercial offerings and concluded that several of these might be suitable for SAAM. The second type of failures can best be dealt with by using a backup server. No commercial product meets the stringent requirement of SAAM service availability. We developed a protocol that can detect server failure and resume full service within fractions of a second. The backup server uses adaptive polling, with the cycle time becoming persistently smaller with each unanswered probe, to detect and verify primary server failure in a timely and reliable manner.

(4) System Security: Security is particularly important for SAAM because SAAM uses mobile code, called resident agents, to extend router services. The server loads these resident agents onto routers dynamically, and the agents then execute on the destination routers. A scheme to authenticate mobile code is required to prevent an outsider from installing a malicious resident agent. Also, all signaling messages in SAAM are authenticated to counter spoofing attacks. We explored the idea of Time-driven Key Sequencing (TKS) to speed up the authentication process. TKS is a scheme for implementing low-overhead key changes in support of the use of efficient cryptographic algorithms. We also developed a Kerberos-based method to authenticate new nodes that join a SAAM network and to refresh authentication keys across the network.

(5) Server Originated Probing: The objective of this work is to add server-based, router performance sampling capabilities to SAAM. As a router may be misconfigured, or worse, actively attacked, a server should not rely entirely on link performance data reported by routers to maintain the network status. We developed a method that gives the server an independent means to validate link performance reports from a router. This way, erroneous performance data can be filtered out before it causes severe service degradation.

(6) Path-based network Policy Language (PPL): Existing network policy languages define policy rules on a per node basis. PPL's path-based approach for representing network policies is advantageous in that QoS and security policies can be associated with an explicit path through the network. This assignment of policies to network flows aids in new initiatives such as Integrated Services. The more stringent requirement of supporting path-based policies can be easily relaxed with the use of wild card characters to also support Differentiated Services and best-effort service. Path-based policies have a complexity advantage over node-based ones as well.

(7) Configuration Management: We formalized and simplified SAAM testbed configuration management. We defined a SAAM configuration language using XML and developed a GUI based application to help users create test configurations in the defined language. The demo-station was also modified accordingly; it now sets up a SAAM testbed by reading a test configuration file.

PUBLICATIONS:

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Xie, G.G. and Gibson, J. A., "Networking Protocol for Underwater Acoustic Networks," Naval Postgraduate School Technical Report, December 2000.

PRESENTATIONS:

Xie, G.G., "Signaling, Security, and A Policy Language for SAAM," DARPA Next Generation Internet PI Meeting, McLean, VA, October 2000.

Xie, G.G., "The Next Generation Internet," MOVES Open House, Monterey, CA, August 2000.

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Ababneh, M., "Network Configuration Using XML," Masters Thesis, Naval Postgraduate School, September 2000.

Velazques, L. and Szczepankiewicz, P., "Authentication in SAAM Routers," Masters Thesis, Naval Postgraduate School, June 2000.

Akkoc, H., "A Pro-Active Protocol for Configuration of Signaling Channels in Server and Agent-based Active Network Management (SAAM)," Masters Thesis, Naval Postgraduate School, June 2000.

Uysal, H.H., "A Model for Generation and Processing of Link State Information in SAAM Architecture," Masters Thesis, Naval Postgraduate School, March 2000.

Kati, E., "Fault Tolerant Approach for Development of SAAM Server in Windows NT Environment to Provide Uninterrupted Services to Routers," Masters Thesis, Naval Postgraduate School, March 2000.

Quek, H.C., "QoS Management with Adaptive Routing for Next Generation Internet," Masters Thesis, Naval Postgraduate School, March 2000.

Altinkaya, M., "Server Probing for Server and Agent Based Active Network Management," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control and Communications

KEYWORDS: Network Management, Integrated Services, Asynchronous Transfer Mode (ATM), Quality of Service (QoS), Policy Based Networking, Network Security

**DEPARTMENT OF
COMPUTER SCIENCE**

**Faculty Publications
and Presentations**

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**DEPARTMENT OF
COMPUTER SCIENCE**

Thesis Abstracts

THESIS ABSTRACTS

NETWORK CONFIGURATION USING XML

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Master of Science in Computer Science-September 2000

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The primary goal of this thesis is to investigate the use of the Extensible Markup Language (XML) as a network configuration language. Network configuration is a difficult and time-consuming task. Current network configuration solutions are based on proprietary configuration languages and parsers. XML is a platform-neutral data representation language and worldwide standard. It potentially advantageous to use XML to configure networks. However, XML was not developed for network configuration. A new XML based configuration solution for the Server and Agent Active Network Management System (SAAM) is provided to marshal evidence that XML can be used effectively as a network configuration language.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: XML, Quality of Service, Network Configuration, Next Generation Internet, Networks

EXTENSIBLE INTEREST MANAGEMENT FOR SCALABLE PERSISTENT DISTRIBUTED VIRTUAL ENVIRONMENTS

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Eventually there will exist virtual environments inhabited by millions, but as virtual environments grow in size and number of entities, many problems emerge. Because of these problems, increasing attention is being brought to the issue of filtering data that is not of interest to a given client. Such filtering is known as *interest management*.

This dissertation outlines a three-tiered approach to interest management. The first tier breaks the world into manageable pieces. The second tier uses the data from the first to create a protocol independent perfect match between a client's interests and the environment. The third tier, building on the second, adds protocol dependence allowing the client to receive only the data from the protocol it needs. At the same time, separating out the protocol from the core interest management can allow multiple protocols to simultaneously exist within the same environment, while using the same underlying filtering mechanism. Results from this work have shown that it is possible to create an interest management software architecture that allows bandwidth, packets per second, and CPU time to scale dependent only on the number of entities a given client is interested in at any one time.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Simulation, Multicast, Interest Management, Distributed Virtual Environments, Bamboo

THESIS ABSTRACTS

ANALYSIS OF MECHANISMS FOR TCBE CONTROL OF OBJECT REUSE IN CLIENTS

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This study contributes to the realization of a high assurance Multilevel Secure Local Area Network. They system consists of a Trusted Computing Base (TCB) that acts as a server base. Clients are Commercial-off-the-Shelf (COTS) workstations and software, augmented with a hardware-based TCB Extension (TCBE). This work concentrates on object reuse control on the client, which is one of the security services to be provided by the TCBE.

Object reuse mechanisms are designed to assure that sensitive information does not persist across sessions of session level changes. Twenty-nine chips on the PC motherboard were analyzed. Possible solutions were proposed and evaluated for object reuse control of four storage areas: main memory, AGP memory, cache and Real Time Clock (RTC) memory. The feasibility of one proposed solution was demonstrated.

It was found that main memory can be cleared by slowing its refresh rate. It was determined that AGP memory cannot be read out by devices on the PCI and ISA bus. The Intel INVD command can be used to clear cache. RTC memory can be accessed and its integrity checked by TCBE software.

This study establishes a foundation for object reuse control efforts targeting COTS PC products manufactured by various vendors.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Other (Information Security)

KEYWORDS: Multi-level Secure Local Area Network (MLS-LAN), Trusted Computing Base (TCB), TCB Extension (TCBE), Object Reuse, Secure Systems, Object, Subject, Computers, Networking, Information Security

A PRO-ACTIVE ROUTING PROTOCOL FOR CONFIGURATION OF SIGNALING CHANNELS IN SERVER AND AGENT BASED ACTIVE NETWORK MANAGEMENT (SAAM)

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As networks are upgraded to provide services for streaming applications, the current way of routing is not satisfactory. Server and Agent based Active network Management (SAAM) introduces a novel network architecture that provides guaranteed quality of services to real-time traffic. In SAAM, the server and routers need to establish two-way, robust, and efficient signaling channels for exchange of control and management information. Any change in network topology must be determined and handled as they occur in order to support guaranteed services. Local detection of topological changes and hop-by-hop dissemination of knowledge of these changes is not optimal for SAAM architecture. A reactive method of updating routing tables takes longer time than tolerable for real-time traffic. Therefore, a pro-active approach that re-configures the signaling channels in real time and without degrading services to user traffic is mandatory. This thesis presents such a pro-active routing protocol for configuring the signaling channels of a SAAM region.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software

KEYWORDS: Routing Protocol, Signaling Channel Configuration, Soft-State Approach, Pro-Active Approach, Networks

THESIS ABSTRACTS

SERVER PROBING FOR SERVER AND AGENT BASED ACTIVE NETWORK MANAGEMENT

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In Server and Agent Based Active Network Management (SAAM) architecture, a server will make routing and other important decisions on behalf of the routers in its region. In order to make the right decisions and to support QoS (e.g., IntServ and DiffServ), the SAAM server needs to maintain an accurate region-wide view of network performance. This will be achieved as routers periodically send Link State Advertisement (LSA) messages to the SAAM server. Currently, the LSA messages report two key Link Performance Statistics, the average delay and the loss rate experienced by packets. Moreover, the server needs to perform sanity checks of these statistics by probing specific links. This thesis describes a server probing solution in which the SAAM server probes a router by dynamically injecting customized probing programs into the adjacent routers. In other words, the probing will be done with the active networking approach. An important feature of the server probing solution is that the probing activities cannot be detected by the router being probed.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Active Networking, Quality of Service, Networks

AN INTELLIGENT AGENT SIMULATION OF SHIPBOARD DAMAGE CONTROL

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A fire on board a ship presents special challenges. It requires not only special anti-fire devices but well-trained teams of firefighters. Since crews rotate periodically, there is a need for ongoing personnel training and not all crew members have the same amount of training. A significant problem is how to assess the effectiveness of a team of firefighters with different skills in a real situation. A team should work together efficiently and follow standard procedures correctly if it is to successfully extinguish the fire within a reasonable period of time and with minimum damage. The question is: What skills are of most importance to a successful team of firefighters? It is difficult to carry out physical experiments without risking human lives and material losses. This thesis uses a reactive agent-based simulation to study the importance of different firefighting skills and anti-fire devices to the prosecution of fire on board a ship.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Human Systems Interface

KEYWORDS: Artificial Intelligence, Fire, Firefighters, Firefighting Skills, Anti-Fire Devices, Stochastic Modeling

THESIS ABSTRACTS

TESTING AND EVALUATION OF THE SMALL AUTONOMOUS UNDERWATER VEHICLE (AUV) NAVIGATION SYSTEM (SANS)

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At the Naval Postgraduate School (NPS), a Small AUV Navigation System (SANS) was developed for research in support of shallow-water mine countermeasures and coastal environmental monitoring. The objective of this thesis is to test and evaluate the sans performance after tuning the filter gains through a series of testing procedures.

The new version of SANS (SANS III) used new hardware components which were smaller, cheaper, and more reliable. A PC/104 computer provided more computing power and, increased the reliability and compatibility of the system.

Implementing an asynchronous Kalman filter in the position and velocity estimation part of the navigation subsystem improved the navigation accuracy significantly. To determine and evaluate the overall system performance, ground vehicle testing was conducted. Test results showed that the SANS III was able to navigate within ± 15 feet of global positioning track with no global positioning update for three minutes.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: INS, GPS, AUV, SANS, Navigation, Kalman Filter

NAVAL ARCHITECTURE ENVIRONMENT: FACILITATING JV2010

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This thesis demonstrates that the Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Framework Version 2.0 requirements can be satisfied with one modern object oriented CASE tool. It provides an alternative scenario-centric approach to architecture development. The combination of scenarios and Unified Modeling Language (UML) semantics is referred to as the Naval Architecture Environment (NAE). Specifically, it recommended the acquisition of Rational Rose.

The NAE combines the best practices of software development with the domain-specific insight contained in the Framework to create an efficient process, supported by a commercial tool and robust semantics, to allow the analysis and design of interoperable C4ISR systems. These are systems that will support Joint Vision 2010's call for Information Superiority.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: C4ISR, Architecture, Unified Modeling Language (UML)

THESIS ABSTRACTS

IMPLEMENTING AN INTRANET-BASED PERSONNEL DATA SYSTEM IN COMBAT ARM SCHOOLS

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This thesis presents a model of intranet implementation for a military organization. The model includes the design and implementation of a relational database for a personnel department which is connected to the intranet. The database connectivity from back-end to front-end constructed by Active Server Pages (ASP), enables the users to manipulate the database via their web browsers.

From the technical aspect, in order to achieve a successful and secure intranet implementation, several software and hardware components are reviewed and some are recommended. The intranet pages are built with Microsoft Front Page 98. This prototype will be a first and big step for this organization to initiate a transformation from the traditional manual world to a digitized world. Therefore, it is highly expected that there will be a change problem in the organization. From the management aspect, specific change strategies are suggested to manage change.

DoD KEY TECHNOLOGY AREA: Other (Internet, Intranet, Database and Security)

KEYWORDS: Intranet, Internet Technology, Information Technology, Database, and Web-Database Connectivity

WEB SERVER CONFIGURATION FOR AN ACADEMIC INTRANET

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The Internet has undergone a tremendous growth in the past decade. After the evolution of personal computers and the radical decrease of their prices, people have the ability to access all the massive information that only the Internet and the World Wide Web can provide. One of the factors that boosted this ability was the evolution of the Web Servers. Using the Web Server technology man can be connected and exchange information with the most remote places all over the world. So, the web can be thought as a mass medium. This study will provide the necessary information required to configure a Web Server within the boundaries of an academic Intranet. It will also serve as an example for both Greek and US DoDs or other organizations seeking to implement a Web Server as an improvement to their existing Servers.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Web Server, Web Browsers, Intranet

THESIS ABSTRACTS

COMMAND AND CONTROL DATA DISSEMINATION USING IP MULTICAST

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Second Reader: John Iaia, Space and Naval Warfare Systems Center-San Diego

Tools have been developed which allow tactical data to be exchanged over Internet Protocol networks, but the quality of service necessary to operate these tools is not available for most Naval vessels at this time. The objective of this thesis is to show that using Multicast IP, distributing data in layers using an efficient protocol, and sending data with no inherent mechanism to ensure that packets arrive at their destinations will allow data to be exchanged over IP networks at much lower bandwidths than is required today while still maintaining a common tactical picture. Software was developed which interfaces to GCCS-M and exchanges data over a multicast network. This software was tested in a laboratory which simulated a Naval environment. The results of testing demonstrate the potential of using the characteristics of the track data being exchanged in a true multicast architecture to develop a efficient tactical data distribution system for users operating in the Naval environment.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software

KEYWORDS: Multicast, Command, Control, Communications, Common Operational Picture

SUPPORTING A TRUSTED PATH FOR THE LINUX OPERATING SYSTEM

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The existence of Trojan horses, viruses, and other malicious software has motivated the computer security industry to invent mechanisms that protect against malicious software. One such mechanism is called the Trusted Path. The Trusted Path provides a way for the system to authenticate itself to the user. Once invoked, the Trusted Path provides an environment in which the user can perform trusted operations such as login, logout, and change password.

This thesis provides a high level design for a Trusted Path and an in depth analysis of how a Trusted Path can be implemented in the Linux operating system. Research of process family creation and keyboard handling has led to the implementation of a Secure Attention Key that can be used to invoke a Trusted Path in Linux.

This research is meant to be used in combination with other efforts to enhance the Linux operating system as an inexpensive platform for instruction on computer security policies.

DoD KEY TECHNOLOGY AREAS: Other (Secure Computer Systems, Computer Security, Information Assurance)

KEYWORDS: Trusted Path, Secure Attention Key, Computer Security, Linux, Policy Enhanced Linux

THESIS ABSTRACTS

DISTRIBUTED RELATIONAL DATABASE SYSTEM OF OCCASIONALLY CONNECTED DATABASES

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Master of Science in Computer Science-March 2000

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Second Reader: Chris Eagle, Department of Computer Science

The Troop Command at the Presidio of Monterey requires an information system that will provide timely and accurate data about all serviced troop activities with students and permanent party stationed at the Defense Language Institute Foreign Language Center. Data sources that could provide required information already exist, but are physically spread over the Presidio, are maintained in diverse formats, and are not interconnected. Some data sources, maintained by other activities located at the Presidio, are available on the Campus Area Network. As new technologies emerged, it became possible to integrate all available data sources into a heterogeneous distributed information system, in which some information will be shared, while other information will be under some degree of local control. This thesis studies the feasibility of such an information system, and proposes one possible implementation.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Distributed Database, Heterogeneous Database System, PowerBuilder 7, SQL Server 7

DISTANCE PERCEPTION AND VISUALIZATION USING VIRTUAL ENVIRONMENTS

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Master of Science in Modeling, Virtual Environments and Simulation-September 2000

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Second Reader: Barry Peterson, Department of Computer Science

The studies in this thesis include experiments in training transfer, metric and visual feedback, field of view within the visual display, and cognitive relationships with distance perception. Participants were tested to show positive training transfer, retention of training, and organizational skills. Participants were trained to judge the distance perception in the in-depth plane, given a distance in a frontoparallel plane and also trained to judge perceived distances from themselves to an object. Experiment one shows that a positive training transfer exists from the virtual to the real world and visa versa. Experiments two and three show that perceptual feedback gives more information than metric feedback. Experiment four shows that between 30 – 60 degree geometric field of view setting should be used for optimal performance on distance estimation tasks using an HMD with 60-degree optical FOV. Experiment five shows that there is no correlation between how well participants organize symbols and how well they can be trained to judge distances. Experiments also confirm that as distances increased so did the amount of error.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Distance Perception, Feedback, Human Factors, Human Error, Modeling, Manpower, Personnel and Training, Simulation, Training Transfer, Virtual Reality

THESIS ABSTRACTS

A COMPUTER SIMULATION APPROACH TO THE STUDY OF EFFECTS OF DECK SURFACE COMPLIANCE ON INITIAL IMPACT IMPULSE FORCES IN HUMAN GAIT

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Master of Science in Mechanical Engineering-March 2000

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The Navy's leadership is looking at improving quality of life and reducing long term health problems through the reduction of knee disorders. One proposal for reducing knee disorders is to install more compliant decking. The goal of this thesis is to develop a computer model of the human gait that estimates the transarticulation forces in the knee during walking on various surfaces. This model can be used to evaluate the reduction of the heel strike forces during walking when deck surface modifications are made. Previous analytical and computer models of the human gait are reviewed. The major contribution of this thesis is a detailed dynamic model of foot-ground interaction during the initial phase of load bearing in human gait.

DoD KEY TECHNOLOGY AREAS: Biomedical, Computing and Software, Manpower, Personnel, and Training, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Human Gait, Computer Model, Simulation, Deck Surface Compliance, Ground Reaction Forces, Dynamics

FACILITATING SECURE MAIL IN A HIGH ASSURANCE LOCAL AREA NETWORK

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Master of Science in Systems Engineering-September 2000

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Second Reader: James P. Anderson, James P. Anderson, Inc.

Currently, almost all DoD systems are operated at a single level, classified or unclassified. The problems encountered on these single level systems with mail exchange, its storage, and manipulation are the multiple networks and workstations required to handle different security levels of data as well as the high cost of maintaining them. The Naval Postgraduate School Multilevel Secure Local Area Network (MLS LAN) project supports a high assurance server. This LAN is COTS-driven (commercial-off-the-shelf) and enforces a mandatory security policy while permitting users to employ standard office productivity tools on standard workstations. Initially, there was no means for multilevel mail exchange between clients of the system.

This research was to implement the simple mail transfer protocol (SMTP) server, Sendmail, on the Wang Federal XTS 300 as a multilevel server. A port of a UNIX version of Sendmail 8.9.3 was made to the XTS 300. Modifications to Sendmail were required so that it could be supported by the UNIX-like XTS 300 STOP 4.4.2 operating system. Sendmail proved to be a successful mail server for exchange of mail between system clients. Tests demonstrated successful transmission of simple mail and mail with attachments.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Multilevel Security (MLS), MLS Local Area Network (LAN), High Assurance, Sendmail, Commercial-off-the-Shelf (COTS), Platform, Server, Client, Trusted Path, Trusted Computing Base (TCB), Wang Federal XTS 300

THESIS ABSTRACTS

A NEW PARADIGM FOR MIGRATING TO CONVERGED INTEROPERABLE NETWORKS

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Master of Science in Information Technology Management-September 2000

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In both the military and the commercial sector, requirements for interoperability between systems have grown. The fact that requirements change rapidly in the information age and that customer needs are unknown and often impossible to correctly predict has created the need for an architecture for communication systems that affords flexibility and interoperability. As an alternative to solving the interoperability problem for individual systems, the thesis introduces an object-based network interoperability model in which every system should be designed as a network object. In this thesis a case study of replacing technologies for the existing IPv4 protocol is presented.

At the same time that the demand for interoperability increases, the customer demands that modern communication solutions like telephony- and video-conferencing is implemented to incur savings. Evolving constraint-based routing technology for implementation of a multi-service network that can support full communication interoperability is also investigated as part of this thesis. As a practical example, the Norwegian Defense InterLAN (a nationwide military WAN in Norway) is used to discuss architectural issues and the techniques for migration strategies towards multiservice networks.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Networking, Interoperability, Communication, Converging Networks, Real-Time Services, Quality of Service, Multi-Service Networks, IPv6

THE ROLE OF PERSONALITY IN DETERMINING VARIABILITY IN EVALUATING EXPERTISE

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Master of Science in Modeling, Virtual Environments and Simulation-September 2000

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Second Reader: Barry Peterson, Department of Computer Science

This research investigated how different experts in a single domain chose their individual subjective evaluation criteria of a highly aggregate task based upon their individual differences. The Conning Officer Virtual Environment (COVE) was utilized to provide a domain of experts and a subjectively evaluated task. One hundred sixteen expert shiphandlers were investigated to understand how their personality affects their evaluation of a novice performing an underway replenishment (UNREP). The experts were issued a survey that inventoried their personality, UNREP evaluation criteria, and shiphandling style. In general, the participant experts were lower in neuroticism and higher in extraversion and conscientiousness than the average adult. Extraversion appeared to be correlated with the expert's desire to use sensory input as a critical evaluation criterion ($\square = .18$) while openness was correlated with analytical input ($\square = .16$) and UNREP style ($\square = .16$) as critical evaluation factors. Also correlated with UNREP style was agreeableness ($\square = .16$). Finally, the expert's level of conscientiousness correlated with the critical evaluation criteria of analytical input ($\square = .17$) and sensory input ($\square = .39$). Results from this research provide insight to the link between observed behavior and its subjective evaluation and will allow COVE's programmers to develop an intelligent tutoring system (its) that will customize the automated training process.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Shiphandling, Virtual Reality, Intelligent Tutoring Systems, Interactive Learning Environment, Virtual Environment, Surface Warfare, Computer Simulation, Underway Replenishment, Computer Graphics, Personality, Individual Differences, NEO-FFI, Five Factor Model

THESIS ABSTRACTS

DESIGN, IMPLEMENTATION, AND ANALYSIS OF THE PERSONNEL, OPERATIONS, EQUIPMENT, AND TRAINING (POET) DATABASE AND APPLICATION PROGRAM FOR THE TURKISH NAVY FRIGATES

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Master of Science in Computer Science-March 2000

Master of Science in Management-March 2000

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Lee Edwards, Department of Systems Management

The Turkish Navy frigates have a challenging mission, which encompasses tactical, operational and administrative tasks. Lacking an automated information infrastructure hinders the ships' ability to efficiently perform the administrative activities, to generate the required reports quickly and to make effective decisions based on this information.

The objective of this thesis is to design and implement the Personnel, Operations, Equipment, and Training (POET) Database and Application Program for the Turkish Navy frigates and to analyze the potential benefits that will be obtained by using this system. The POET database system will provide the Turkish Navy frigates with an automated information system that will support the administrative activities, release manpower to perform other duties and reduce the productive power loss by increasing the availability, accuracy, and consistency of the data.

The thesis covers the analysis of requirements, conceptual database design using Semantic Data Model, logical database design on Microsoft Access DBMS, and implementation of the application program using Java and JDBC API. The result of this study is a functional application that will eliminate most of the current problems onboard the frigates and result in considerable savings of personnel power and time while providing the required information to the command quickly.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel, and Training

KEYWORDS: Database, Relational Database System, Semantic Data Model, Java, JDBC, System Maintenance, Design, Implementation and Analysis of Information Systems

FIDELITY OPTIMIZATION IN VIRTUAL ENVIRONMENTS

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M.S., University of North Carolina at Chapel Hill, 1996

S.M., Massachusetts Institute of Technology, 1999

Doctor of Philosophy in Computer Science-June 2000

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Committee Members: Donald P. Brutzman, Undersea Warfare Academic Group

Rudolph P. Darken, Department of Computer Science

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In virtual environment systems, the ultimate goal is delivery of the highest-fidelity user experience possible. This dissertation shows that is possible to increase the scalability of distributed virtual environments (DVEs), in a tractable fashion, through a novel application of optimization techniques. Fidelity is maximized by utilizing the given display and network capacity in an optimal fashion, individually tuned for multiple users, in a manner most appropriate to a specific DVE application.

This optimization is accomplished using the *QUICK* framework for managing the display and request of representations for virtual objects. Ratings of representation Quality, object Importance, and representation Cost are included in model descriptions as special annotations. The *QUICK* optimization computes the fidelity contribution of a representation by combining these annotations with specifications of user task and platform capability.

This dissertation contributes the *QUICK* optimization algorithms; a software framework for experimentation; and associated general-purpose formats for codifying Quality, Importance, Cost, task, and

THESIS ABSTRACTS

platform capability. Experimentation with the *QUICK* framework has shown overwhelming advantages in comparison with standard resource management techniques.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Distributed Virtual Environment, Linear Programming, Computer Graphics, Resource Management

COMPUTER-AIDED RECOGNITION OF MAN-MADE STRUCTURES IN AERIAL PHOTOGRAPHS

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Master of Science in Computer Science-December 1999

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Aerial image acquisition systems are producing more data than can be analyzed by human experts. Most of the images produced by remote sensing satellites, including military ones, never get seen or inspected. In this work, automated detection and recognition of buildings in aerial photos is explored. Connectivity analysis is performed on graphs derived from line segment representations of the original images, obtained with the use of the Radon Transform. The model is experimentally validated using 2-meter panchromatic aerial photographs from the National Aerial Photography Program (NAPP), which is a marginally adequate resolution for the recognition of small buildings.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Aerial Photograph Analysis, Pattern Recognition, Imagery Intelligence

DEMONSTRATION OF A CONCURRENTLY PROGRAMMED TACTICAL LEVEL CONTROL SOFTWARE FOR AUTONOMOUS VEHICLES AND THE INTERFACE TO THE EXECUTION LEVEL CODE

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The desire for use of autonomous robotic vehicles has undergone tremendous growth in the past decade. One of the greatest challenges to the successful development of truly autonomous vehicles is the ability to link logically based high-level mission planning with low-level vehicle control software, without a labor intensive programming effort for each mission.

This challenge can be effectively achieved through the use of tri-level control software architecture, as described in the Rational Behavior Model. The control software (in the tactical level) must de-couple the high-level mission planning from the low-level vehicle control software to reduce the programming effort for each mission. This report describes an object-oriented, modular architecture for the middle (tactical) level that uses concurrent programming techniques and multi-language interfacing. This design enables the control software to handle the intense data management effort required to operate in an autonomous fashion and interface with code already perfected for use in the strategic (top) and execution (bottom) levels.

The design was evaluated by providing the tactical level with a simple execute order statement that was then used to drive the actions of the vehicle. The software package demonstrates the validity of the design and provides the framework for full implementation on an actual vehicle.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles - Ships and Watercraft, Other (Autonomous Vehicle Control Software)

KEYWORDS: Autonomous Vehicle, Robot, AUV, Rational Behavior Model, RBM, Concurrency, Ada 95, Control Software

INTELLIGENT AGENTS FOR INFORMATION SYSTEM OPERATIONS (U)

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and

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This paper discusses new information operations concepts related to the use of intelligent agents. The basic agent concept involves dispatching a group of processes across a network to service a user's request at remote locations and to return selected results. With the growth of high bandwidth backbones, networks, and the expanded use of mobile computing, agents fill an essential niche as extensions of the user. Agents assist users in coping with the ever-increasing extent of information available from a host of heterogeneous sources including the internet.

Agents operate autonomously, have rules that constrain their operations, and are reactive to changes they detect in their environment. Advanced agents interact and collaborate with other agents and learn from their experiences. Other advances include increasingly sophisticated abilities to adapt their behavior. In networked environments, agents can be mobile to seek the information they need or to follow their user. For mobile users who only connect to a network periodically, the intelligent agent can act as a surrogate representative.

Agent technology depends on the use of standards and technologies to support requested services. In this thesis, 21st century aspects of this technology are discussed, including concepts for information acquisition, protection, processing, transport, and management.

DoD KEY TECHNOLOGY AREA: Other (Intelligence)

KEYWORDS: Artificial Intelligence, Intelligent Agents, Information Operations

ARCHITECTURAL DESIGN AND PROTOTYPING OF A WEB-BASED WARGAME SIMULATION FOR CAMPAIGN PLANNING EXERCISES

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MAJ Leroy A. Jackson, USA, TRADOC Analysis Center-Monterey

The Campaign Planning Exercise (CAMPEX) War Game is being used for the training of the students of the Air War College in the area of the Air Campaign Planning and the Ground Forces Deployment. The CAMPEX life cycle started in 1986 and the last version was released in 1994. Microsoft Basic Version 7.10 Professional Development System was used for its development. CAMPEX was not designed or developed with the Objected Oriented Technique, so further extension and its use as component for Distributed Components Applications is not feasible.

TRADOC Analysis Center (TRAC) of Monterey plans to use a collection of old Wargames as Components of a Distributed Embedded Application. The CAMPEX Employment Module is the first wargame that will form one of the components of this application, so the redesign and implementation of

THESIS ABSTRACTS

CAMPEX Employment Module with Object-Oriented Technique is necessary. This thesis examines the distributed component architectures available to support the Distributed Embedded Application, re-engineers the CAMPEX Employment Module into an object-oriented design, and validates its requirements via a prototype developed using MicroSoft Access 2000. The new design will be the basis for re-engineering the other wargame planning software for the Air War College.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Modeling and Simulation

KEYWORDS: Battlespace Environments, Distributed Components Architecture, Object-Oriented Design, Modeling and Simulation

HIGH LEVEL ARCHITECTURE PERFORMANCE MEASUREMENT

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Master of Science in Modeling, Virtual Environments, and Simulation-March 2000

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High Level Architecture (HLA) uses an implicit Runtime Infrastructure (RTI) that completely encapsulates all simulation systems. This implementation on a networked virtual environment might be limited and could affect the overall system performance. The performance of HLA on PC workstations in a networked virtual environment might not be determined, and therefore the effects and limitations of its implementation could severely hamper the realism of real-time virtual environments. The goal of this thesis is to determine the limitations of the HLA in a networked virtual environment on the Windows NT platform. In identifying the limitations of HLA, we will be able to ascertain the areas in which HLA can be improved. This thesis implements and measures the system performance of three different setups, namely a standalone virtual environment, a networked virtual environment using HLA, and a networked virtual environment using User Datagram Protocol (UDP). The system performance measured includes average CPU, network, graphics and memory processing requirements, frame rate per second, and the reliability of data received. The results indicate the use of heavily threaded processes by HLA significantly reduces overall system performance.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: High Level Architecture, User Datagram Protocol

COMPARISON OF VEGA™ AND JAVA3D™ IN A VIRTUAL ENVIRONMENT ENCLOSURE

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and

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Michael J. Zyda, Department of Computer Science

Large enclosures offer a myriad of possibilities for virtual environments and can dramatically improve presence for a number of applications. Scene graphs are accepted as the logical and optimized way to generate and render applications, however most scene graphs are proprietary or platform specific. Open source scene graphs are emerging that are easily used and cross-platform.

This thesis describes the physical construction of a large sized Multiple Angle Automatic Virtual Environment (MAAVE) and the programming of visual simulations using Vega, a powerful commercially

THESIS ABSTRACTS

available software package, and Java3D, an open source scene graph. The two simulations are networked walkthrough virtual environments using the same geometry.

After the MAAVE was built, the two applications were tested on multiple platforms with frame rate being the main measure of performance. Initial expectations were that Vega would be faster, but the ease and speed of development of each application was unknown. Results showed that the Vega application was 10 to 30 times faster on sgi hardware and 4 to 20 times faster on a standard PC. The Java3D application required one third of the development time and was easier to program. Overall, we conclude that Vega is the better development platform for multi-channel walkthrough applications.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Virtual Environment, Visual Simulation, Scene Graph, Networking, CAVE, MAAVE

DECISION SUPPORT FOR SOFTWARE PROCESS MANAGEMENT TEAMS: AN INTELLIGENT SOFTWARE AGENT APPROACH

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Currently, SPAWAR Systems Center is lacking a unified software development environment that would assist software developers to effectively manage software development projects, across a heterogeneous development environment. This unified environment is needed to provide up-to-date accurate information to the right people at the right time, increase the process knowledge base, increase productivity, decrease time-to-market, eliminate redundancy, and ease job stress.

This thesis proposes a conceptual model for software process management decision support in the form of an intelligent software agent network. The intelligent software agent network, called MENTOR, provides the knowledge base that is integral to the software development team, providing for a repeatable, defined, managed, and optimized development environment. This concept provides SSC software development managers and team members with the ability to work in a unified and collaborative environment, regardless of organizational diversity or location.

MENTOR will be utilized as an integral software development team member, providing tutorials and mentoring capabilities for management and process assistance, as well as providing process planning, risk analysis, and strategic planning recommendations for the successful completion of a software development effort at all team levels. In addition, MENTOR will provide an effective communication environment that will enable the development team to minimize the time consuming workload involved in tracking individual tasking.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Intelligent Agents, Software Management, Software Process Guide

DYNAMICALLY DETERMINING DISTRIBUTION STATISTICS IN A DISTRIBUTED ENVIRONMENT

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Currently, the Department of Defense runs its special purpose applications on dedicated hardware i.e., on "stovepipe systems." Such hardware has inherent disadvantages. They have an inability to handle the resource contention that often occurs upon the influx of a large number of applications. A new application

THESIS ABSTRACTS

needing to use a given resource must typically wait for any preceding applications to first finish their use instead of searching out another capable resource. An even worse scenario is when the system fails and no applications can run until the system is repaired and brought back on-line. In all the cases, important decisions can potentially be delayed or made without important information. The Management System for Heterogeneous Networks (MSHN) will mitigate these deficiencies. The goal of MSHN is to manage several different types of applications across a changing heterogeneous network. MSHN determines the best resource on which to run an application based on both the application's and overall system's Quality of Service (QoS). The focus of this thesis is to write and demonstrate for MSHN the worth of an algorithm that can determine and update distribution statistics for the end-to-end QoS resource usage of an application program. These distributions are vital in assisting MSHN in the scheduling and rescheduling of applications across a network.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Resource Management System, Distributed Systems, Client Library, Resource Monitoring, Stochastic Algorithms, Distribution, Heterogeneous Computing

COM AND XPCOM AS A SOLUTION TO BAMBOO'S VERSIONING PROBLEM

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Michael V. Capps, Department of Computer Science

Second Reader: Kent Watsen, Department of Computer Science

Bamboo is a systems toolkit that is primarily concerned with supporting performance-critical applications that must run continuously for extremely long periods of time. Bamboo supports this by managing the loading and unloading of executable code into and out of process memory at runtime. Thus, as application requirements change over time, obsolete code can be replaced without having to restart the application. This technique's flexibility has already been demonstrated, but fails in one critical way. Although the C++ programming language standard defines a consistent syntax, it fails to specify a consistent binary encapsulation. Thus, if the executable code for a C++ base class is dynamically replaced, it is very likely that its in memory layout differs from before and therefore incompatible with whatever derived classes may exist. The only recourse is to recompile and reload the derived classes as well.

Component Object Model (COM) and Cross Platform Object Model (XPCOM) solve C++ weakness by enforcing a complete separation of a class's interface from its implementation. This thesis demonstrates support for dynamic versioning of Bamboo C++ modules using COM and XPCOM.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: The Versioning Problem, Component Object Model, Cross Platform Object Model

RE-PURPOSING COMMERCIAL ENTERTAINMENT SOFTWARE FOR MILITARY USE

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Master of Science in Modeling, Virtual Environments and Simulation-September 2000
and

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B.M.E., Auburn University, 1992

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Michael J. Zyda, Modeling, Virtual Environments and Simulation Academic Group

Virtual environments have achieved widespread use in the military in applications such as theater planning, training, and architectural walkthroughs. These applications are generally expensive and inflexible in

THESIS ABSTRACTS

design and implementation. Re-purposing these applications to meet the dynamic modeling and simulation needs of the military can be awkward or impossible.

Video games are designed to be both technologically advanced and flexible in design. We evaluated current games and modified Quake 3 Arena™ (Q3A) to serve as both an architectural walkthrough and a primitive team trainer. To accomplish this, a real Naval Postgraduate School building was incorporated into Q3A. The game's source code, characters and their behaviors, weapons models and characteristics, and overall gameplay was modified.

By re-purposing commercial entertainment software, a viable military virtual environment application was produced that is less expensive yet arguably as engaging as current computer-based options. This application was created in approximately 300 man-hours with a cost of \$6780 (including hardware) -far less than the development time and cost of similar military virtual environment applications. Game evaluations included in this thesis facilitate and inform similar modification efforts by highlighting entertainment technology available in the year 2000 game market.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Modeling and Simulation, Software Re-Purposing, Video Games, Entertainment Technology, Architectural Walkthrough, Game Modification

EFFECTIVE SPATIALLY SENSITIVE INTERACTION IN VIRTUAL ENVIRONMENTS

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Michael V. Capps, Department of Computer Science

Effective interaction techniques are critical for productive use of virtual environments for business, manufacturing, and training. This thesis addresses the need to match the dimensionality of tasks performed in a virtual environment to the dimensionality of the techniques used to perform the tasks.

In order to demonstrate the performance benefits of matching the dimensionality of task and technique, an experiment was conducted in which twenty-seven subjects were asked to perform a series of two and three-dimensional tasks. Subjects were required to perform all tasks using only three-dimensional techniques, then only two-dimensional techniques, and finally a combination of both techniques.

The results clearly showed that matching the dimensionality of the task to the dimensionality of the interaction technique achieved the best performance in a virtual environment. Of 27 subjects, 90% preferred to use a technique whose dimensionality matched the requirements of the task. More importantly, 100% demonstrated improved performance when the dimensionality of task and technique matched.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Modeling and Simulation

KEYWORDS: Virtual Environments, Interaction, Interaction Techniques

EXAMINATION OF THE INTERNET MESSAGE ACCESS PROTOCOL (IMAP) TO FACILITATE USER-FRIENDLY MULTI-LEVEL E-MAIL MANAGEMENT

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Master of Science in Computer Science-September 2000

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Second Reader: David J. Shifflett, Department of Computer Science

Information systems within the Department of Defense (DoD) need trustworthy enforcement of critical security policies against sophisticated attackers. Data, such as e-mail, is processed on these systems on a daily basis. Since this data may contain sensitive information, special handling is required to prevent

THESIS ABSTRACTS

unauthorized disclosure. For these reasons, a high assurance Multi-Level secure (MLS) Local Area Network (LAN) was developed to control the sharing of information at different security levels.

A challenge in multi-level environments is to provide a usable and meaningful interface to users via the e-mail clients. These e-mail clients interact with the high assurance server running on the MLS LAN. The high assurance server returns information at security levels at or below those of the client. An e-mail client is only able to write and manipulate mail at its level. Therefore, client systems should provide users with feedback regarding operations they are able to perform.

In this research, six criteria were established to examine e-mail clients. These criteria evaluated messages displayed to users via the e-mail clients. All of the e-mail clients was able to satisfy at least one of the established criteria.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Multi-Level Secure (MLS), Local Area Network (LAN) Discretionary Access Control (DAC) Policy, Mandatory Access Control (MAC) Policy, Commercial-Off-The-Shelf (COTS), Internet Access Message Protocol (IMAP), POP (Post Office Protocol)

DEVELOPMENT OF AN EXPERT SYSTEM AND INTELLIGENT SOFTWARE AGENT FOR AVIATION SAFETY ASSESSMENT

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Master of Science in Computer Science-March 2000
and

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Second Reader: Chris Eagle, Department of Computer Science

The primary goal of this thesis is to design, develop and test an internet based prototype model for using expert system and software agent technologies to automate some of the analytical tasks in conducting aviation safety assessments using the data collected by the automated Aviation Command Safety Assessment (ACSA) system.

The Aviation Command Safety Assessment is a questionnaire survey methodology developed to evaluate a Naval Aviation Command's safety climate, culture, and safety program effectiveness. The survey was a manual process first administered in the fall of 1996. The survey was then automated in 1999 and is administered over the World Wide Web.

The results of this thesis are a prototype model and a software agent application that evaluates data contained in the ACSA database for organizational safety assessment and for database integrity. All source code is provided and discussed in detail.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Database, Java, Expert Systems, Software Agents, Aviation Safety

SECOND GENERATION ULTRA HIGH FREQUENCY (UHF) SATELLITE PROTOCOL

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An attempt is being made to provide the reader with an appreciation for the complexity required to upgrade an existing Ultra High Frequency (UHF) 25 kHz tactical communications protocol. This thesis defines the

THESIS ABSTRACTS

satellite discipline and protocols for a second generation of the Officer in Tactical Command Information Exchange Subsystem (OTCIXS II). This thesis provides the detailed information necessary for the implementation of the OTCIXS II communications protocols. It can be used to define and develop the OTCIXS II satellite link software. The OTCIXS II network protocol will consist of distinct protocol layers: Physical, Data Link, and Network layers. The transport layer which provides the actual computer to computer transfer of messages will not be covered in this thesis.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Other (UHF SATCOM)

KEYWORDS: OTICXS II Satellite Link Protocol

TRUST AND ITS RAMIFICATIONS FOR THE DOD PUBLIC KEY INFRASTRUCTURE (PKI)

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In order to incorporate trust into e-commerce, public key cryptography, and basic communication, one must understand and effectively manage trust. Various internet security protocols have attempted to address this lack of trust. However, these protocols do not incorporate the user's trust into these protocols. Computational models of trust have been developed in an attempt to automate the logic, variables, and thought processes that a human performs when making a trust-decision. Due to the fact that trust is based on a subjective belief, the models require the assignment of metrics to belief variables or attributes that will have value when evaluating trust. These models address the notion of trust in many different ways and both their definitions and metrics vary significantly. This thesis evaluates the various trust models. It is necessary to understand how trust is defined in each model in order to evaluate how well the operation of a system based on the model satisfies the requirements of the users. Trust models are evaluated based on their characteristics, environmental references, metrics, variables used, and outputs. This thesis concludes with the assessment of a practical application of a trust model to the DoD's PKI system.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Trust Models, Trust Management, Public Key Infrastructure (PKI), Computer Security

AN ARCHITECTURAL FRAMEWORK FOR INTEGRATING COTS/GOTS/LEGACY SYSTEMS

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Building distributed systems more effectively and efficiently is an essential goal of the Department of Defense (DoD). We are driven by the push toward greater use of COTS, the need to improve access to legacy data and services, and the new business opportunities offered by web-based technologies and electronic commerce. To fully realize the DoD's goal, a new architectural framework is needed.

This thesis proposes an architectural framework suitable for integrating COTS/GOTS/legacy systems in a distributed, heterogeneous environment. The proposed architectural framework uses The Open Group Architectural Framework (TOGAF) as a basis and includes new tools to support the COTS/GOTS/legacy system development and integration. A case study for the Naval Integrated Tactical Environmental Systems (NITES) program where a prototype is built, demonstrates the effective use of the proposed architectural framework.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: COTS, GOTS, Legacy Systems, Architectural Framework, Distributed Systems, Software Development

THESIS ABSTRACTS

A TASK ANALYSIS OF PIER SIDE SHIP-HANDLING FOR VIRTUAL ENVIRONMENT SHIP-HANDLING SIMULATOR SCENARIO DEVELOPMENT

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Researchers at the Naval Air Warfare Center Training Systems Divisions (NAWCTSD) in Orlando, FL have developed a testbed for the Conning Officer Virtual Environment (COVE) Ship-Handling Simulator. The purpose of this task analysis was to provide a workable document that they could use in the development of pier side ship-handling scenarios for their simulator. The task analysis not only identified the general procedures and methodologies used by a conning officer during pier side ship-handling evolutions but also provided inventories of the perceptual cues that were used specifically for these evolutions.

The approach taken was to use a Goals, Operators, Methods, Selection Rules (GOMS)-like model to represent the logical sequence of methods used by the conning officer. Critical Cue Inventories (CCI) were then developed to supplement the GOMS model by providing a list of the cues used along with detailed descriptions of why the cue was used and how it was visually or audibly identified. The accuracy of the pier side ship-handling task analysis was then validated by interviewing Surface Warfare Officers with several years of ship-handling experience by using the Critical Decision Method (CDM) knowledge elicitation process.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Human Systems Interface, Computing and Software

KEYWORDS: Ship-Handling, Virtual Reality, Task Analysis, Surface Warfare, Computer Simulation, Pier Side Evolutions, Computer Graphics, Virtual Environment

VALIDATION OF A QUALITY MANAGEMENT METRIC

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The quality of software management in a development program is a major factor in determining the success of a program. The four main areas where a software program manager can affect the outcome of a program are requirements management, estimation/planning management, people management, and risk management. In this thesis a quality management metric (QMM) was used to measure the performance of ten software managers on Department of Defense (DoD) software development programs. Informal verification and validation of the metric compared the QMM score to an overall program success score for the entire program and yielded positive correlation. The results of applying the QMM can be used to characterize the quality of software management and can serve as a template to improve software management performance. Future work includes further refining the QMM, applying the QMM scores to provide feedback and appropriate training to program managers, and using the QMM scores as an input to program cost and schedule estimation methodologies to provide better program estimates.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Management, Requirements Management, Estimation/Planning Management, Risk Management, People Management, Quality Management Metric (QMM)

THESIS ABSTRACTS

TESTING AND DEVELOPMENT OF A LOW COST, DIGITAL SIGNAL PROCESSOR BASED TORPEDO COUNTERMEASURE

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Since the early days of submarines, torpedoes have evolved from simple, straight running weapons into advanced vehicles capable of finding and evaluating potential targets. In contrast, torpedo countermeasures have changed relatively little and do not take advantage of inexpensive signal processing technology available today.

Digital Signal Processor (DSP) technology is used extensively in commercial applications making high performance DSP hardware available at relatively low cost. It is now possible to produce low-cost, DSP-based torpedo countermeasures capable of providing better performance than current fleet countermeasures at a fraction of current prices. By analyzing and responding to a threat torpedo's sonar signal only when the threat is actually present, DSP-based countermeasures provide customized decoy signals without having to flood the water with continuous transmissions.

Work on designing, building and testing such a device began at the Naval Postgraduate School (NPS) in 1997. This thesis describes the development, troubleshooting and testing of the NPS second-generation torpedo countermeasure prototypes. Methodologies are presented for hardware and software design efforts and an OpenGL 3D graphics computer simulation is provided. The hardware and software are described in detail along with the testing results and suggestions for future work in this important area.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Conventional Weapons

KEYWORDS: Torpedo Countermeasures, Digital Signal Processing, Acoustic Modem, Acoustic Telemetry, Acoustic Decoy, Signal Analysis

COMPUTER-AIDED SOFTWARE EVOLUTION BASED ON INFERRED DEPENDENCIES

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The major problem addressed by this research is how to automate parts of software evolution using dependency rules, especially for large and complex real-time embedded systems. The main topics of this study are the development of a Relational Hypergraph model (RH model) and the design of a Computer-Aided Software Evolution System (CASES). The goals of this dissertation are to explore the existing issues, to formalize software evolution, to reuse software evolution components, and to build a dependency-computing model. We have resolved parts of essential software evolution issues in the following categories: software evolution process, software evolution traceability, software evolution description, software evolution management, and software evolution control.

The RH model can realize automated software evolution in multi-dimensional phases, such as software prototype or product demo, issue analysis, requirement analysis, specification design, module implementation, program integration, and software product implementation. Many types of software evolution objects in each phase, and dependencies among these objects have been defined to describe software evolution processes. We have developed prototypes of C4I systems to conduct and validate our results.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Electronic Warfare, Manpower, Personnel, and Training

KEYWORDS: Software Evolution, Hypergraph Model, Dependency Rules, Software Reuse, Software Evolution Objects, Software Evolution Processes

THESIS ABSTRACTS

IMPLEMENTATION AND INTEGRATION OF THE OBJECT TRANSACTION SERVICE OF CORBA TO A JAVA APPLICATION DATABASE PROGRAM

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In examining the recent trend of the Client / Server computing technology, it can be seen that distributed object technology is ready to take off. The CORBA (Common Object Request Broker) architecture is the most widely known and readily available candidate for development.

The OMG (Object Management Group), a consortium of object vendors, developed the CORBA standard in the fall of 1990 as a common interconnection bus for distributed objects. Transaction processing is useful not only in database applications but also in building robust mission-critical applications. Utilizing CORBA one can build reliable distributed software systems in a much easier way. CORBA is the most widely accepted standard in this field and there are many CORBA implementations available now. Moreover, the transaction concept is the key to ensure the reliability and availability of Client/ Server applications.

In this thesis transaction properties were applied to a database application program based on Naval Postgraduate School's Course Iteration System. For this purpose an Object Transaction Service was provided based upon the CORBA architecture. It takes advantage of object-oriented programming to help programmers implement transactional applications in a much easier way.

In late 1994, the OMG also published the specification for the object transaction service. This specification is adopted as the blue print for this study. This thesis presents the implementation and integration of the object transaction service based on CORBA.

JDBC (Java Database Connection) was not used for transaction property, because JDBC is currently limited in that it cannot manage transactions across multiple connections. For transaction support across databases or object services, CORBA's Transaction Service provides the best level of abstraction.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Database, Distributed Object Technology)

KEYWORDS: Software, Database, Distributed Object, Corba, OTS (Object Transaction Service), JDBC (Java Database Connectivity), Java

DEVELOPMENT OF A SOFTWARE EVOLUTION PROCESS FOR MILITARY SYSTEMS COMPOSED OF INTEGRATED COMMERCIAL-OFF-THE-SHELF (COTS) COMPONENTS

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Department of Defense (DoD) acquisition policy requires that military system acquisitions incorporate commercial-off-the-shelf (COTS) components into system architectures. Traditional DoD source code development and evolution methodologies do not effectively support COTS-intensive systems. To fully realize the benefits of COTS technologies and products, the DoD must adopt new ways to sustain system evolution in the face of a dynamic market environment subject to constant change.

The thesis proposes a new software evolution methodology to effectively maintain COTS-intensive military systems. The integrated COTS component evolution (ICCE) model provides evolution processes designed to support the maintainer as a consumer of software instead of a source-code developer. The ICCE model affords proactive risk awareness, market awareness, and user awareness activities. The ICCE model also supports a three-tier test and evaluation process. A case study for the U.S. Navy/Marine Corps Meteorological Mobile Facility Replacement (METMF (R)) program demonstrates the effectiveness of the ICCE risk management process.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: COTS, GOTS, Software Evolution, Software Management, Risk Management, Software Evolution Model

TARGET IDENTIFICATION ALGORITHM FOR THE AN/AAS-44V FORWARD LOOKING INFRARED (FLIR)

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Accurate identification of unknown contacts is a crucial issue in military intelligence. In order for this task to be accomplished by human observers, each one must be specially trained and regularly re-qualify. Even with training, their decisions are subject to human error: bias, expectations, or even a lack of sleep may compromise their accuracy. If an automated system could quickly and accurately determine the identity of a contact, it would be a great benefit. This thesis explores some of the problems which must be addressed in producing such a system. We detail an approach to an algorithm which compares a picture of an unknown ship to an established database and determines its most likely classification. In particular, we use infrared images from FLIR video taken at sea, and obtain classification results for a small test set. We tested eighteen images with success rates varying between seventy-three and eighty-nine percent.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Image Recognition, Ship Identification, Hough Transform, Edge Detection

EVALUATION OF THE EXTENSIBLE MARKUP LANGUAGE (XML) AS A MEANS FOR ESTABLISHING INTEROPERABILITY BETWEEN HOMOGENEOUS DEPARTMENT OF DEFENSE (DOD) DATABASES

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This thesis evaluates the application of current Extensible Markup Language (XML) tools and technologies toward solving data interoperability issues between legacy data repositories. Past efforts to address these issues have largely failed. XML has the capability to address many of the past problems, but this can only be accomplished when the supporting COTS tools and technologies are available.

The thesis first establishes the underlying issues that need to be addressed. It then evaluates the current state of technologies and COTS products and describes the advantages and disadvantages of each. Finally, it focuses in on the schema for a specific relational database, demonstrates a process by which data exchange can be implemented, and outlines the issues remaining to be solved.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Extensible Markup Language, Interoperability, Database Management, COTS, Database Interoperability

THESIS ABSTRACTS

ANALYSIS AND DESIGN OF A UNIVERSAL TRAFFIC NETWORK

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and

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As the field of computer networking has evolved, so too has the use of these networks. Modern networks must be capable of performing more than simple data transfer. To be of value, a network must be able to handle the convergence of different types of traffic – voice, video, and data – and the Quality of Service requirements associated with each type.

This thesis performs a detailed analysis of the different types of traffic, the two primary transmission media, fiber optical and copper based connections, and the connection-orientation technology to route the traffic. Presented in this thesis is a fiber-based hybrid network consisting of Asynchronous Transfer Mode at the backbone layer and Frame Relay and Passive Optical Networking at the local access layer. The proposed Universal Traffic Network, based on present-day technology, is a viable solution to the challenge imposed by the convergence of different traffic types.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Computer Networks, Asynchronous Transfer Mode, Frame Relay, SONET, Fiber Optics, Passive Optical Networks, Gigabit Ethernet, Multimedia Communication, Transmission Media

THE ROLE OF EXPERT SYSTEMS IN FEDERATED DATABASE SYSTEMS

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Second Reader: C. Thomas Wu, Department of Computer Science

A shared information system is a series of computer systems interconnected by some kind of communication network. There are data repositories residing on each computer. These data repositories must somehow be integrated. The purpose for using distributed and multi-database systems is to allow users to view collections of data repositories as if they were a single entity. Multidatabase systems, better known as *heterogeneous multidatabase systems*, are characterized by dissimilar data models, concurrency and optimization strategies and access methods. Unlike homogenous systems, the data models that compose the global database can be based on different types of data models. It is not necessary that all participant databases use the same data model. Federated distributed database systems are a special case of multidatabase systems. They are completely autonomous and do not rely on the global data dictionary to process distributed queries. Processing distributed query requests in federated databases is very difficult since there are multiple independent databases with their own rules for query optimization, deadlock detection, and concurrency. Expert systems can play a role in this type of environment by supplying a knowledge base that contains rules for data object conversion, rules for resolving naming conflicts, and rules for exchanging data.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Multidatabase Systems, Federated Databases, Expert Systems, Semantic Networks

THESIS ABSTRACTS

COMPARISON OF PERFORMANCE MEASURES IN THE VIRTUAL ENVIRONMENT AND REAL WORLD LAND NAVIGATION TASKS

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Spatial knowledge acquisition is an integral part of navigation related studies. With the improvement of technology, the researchers gained the capability of testing the spatial ability in a virtual world as well. However, little research has been conducted to understand whether VE performance can predict Real World performance or not and amongst the measures used what measures are most predictive.

This thesis research addresses the validity of performance measures used in virtual and real environments. Ten subjects have participated in two experiments. The first experiment was a navigation task in a building type virtual environment. With some modifications, Hermann Hall model was used for this experiment. The second experiment was a navigation task in a real building. For this experiment Middle East school in DLI was used. Measures of landmark, survey and route knowledge were taken for each participant.

The results did not suggest a correlation in overall performance measures. However a correlation is observed in the performance for the landmark knowledge. The acquisition of survey knowledge by time is also seen in the results of the study.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Virtual Environments, Land Navigation, Spatial Knowledge

FAULT TOLERANT APPROACH FOR DEPLOYMENT OF SERVER AGENT-BASED ACTIVE NETWORK MANAGEMENT (SAAM) SERVER IN WINDOWS NT ENVIRONMENT TO PROVIDE UNINTERRUPTED SERVICES TO ROUTERS IN CASE OF SERVER FAILURE (S)

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The current data networks are mainly based on sophisticated stand-alone routers that provide best effort service. However, with the explosive growth of the Internet and high demand on real-time network applications, the need for integrated service networks has emerged. For this purpose the Next Generation Internet (NGI) Project and as a part of this project the Server Agent based Active network Management (SAAM) project was initiated. SAAM is a server based hierarchical routing architecture designed to provide Quality of Service (QoS) routing services for network resource intensive applications. In the SAAM architecture, a small number of dedicated SAAM servers perform most of the network management tasks on behalf of the routers. The SAAM server has a great responsibility in the SAAM architecture and failure of the SAAM server can have a devastating effect on the performance of the entire network. In order to tolerate the failure of the SAAM server and provide uninterrupted services to routers, this thesis examines the fault tolerance for the SAAM server in two phases: local area fault tolerance, and remote area (disaster recovery) fault tolerance. For the local area fault tolerance, after a survey of the literature and commercial offerings, a recommended solution is proposed. For the remote area fault tolerance, a backup server model is designed and prototyped. The prototyped model provides robust error detection and a fast recovery from the failure of the primary SAAM server.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications

KEYWORDS: Fault Tolerance, Heartbeat Protocol, Next Generation Internet, Networks

THESIS ABSTRACTS

DESIGN OF A DYNAMIC MANAGEMENT CAPABILITY FOR THE SERVER AND AGENT BASED ACTIVE NETWORK MANAGEMENT (SAAM) SYSTEM TO SUPPORT REQUESTS FOR GUARANTEED QUALITY OF SERVICE TRAFFIC ROUTING AND RECOVERY

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The use of interconnected networks has permeated most aspects of society. Along with this explosion in the use of computer networks the demands for increasingly capable applications has placed great demands upon the network transport protocols to ensure to the user high throughput, reliable service, and virtual real-time response. The current Internet, the descendent of the Advanced Research Projects Agency Network, is routed in the Transport Control Protocol/Internet Protocol. This protocol stack has no mechanism for providing guarantees to network clients regarding the quality of service provided. Further, the routing of traffic across the network is router centric, providing no mechanism for optimization of resource allocation to client service requirements. This thesis provides a method for dynamically controlling the allocation of network resources within an autonomous system by a central server. The algorithm significantly improves the performance of the server over the previous prototype and enables the server to add or remove routers from the network topology on the fly in response to status messages from the participating routers.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Next Generation Internet, Integrated Service, Guaranteed Service, Differentiated Service, Best Effort Service, Quality of Service, Flows, Networks, Routing, Path Information Base, Link State Advertisement, Network Resource Allocation

3D VISUALIZATION OF THEATER-LEVEL RADIO COMMUNICATIONS USING A NETWORKED VIRTUAL ENVIRONMENT

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The military is heavily reliant on the transfer of information among various networks in day-to-day operations. Radio-based communications networks that support this volume of information are complex, difficult to manage, and change frequently. Communications network planners need a way to clearly visualize and communicate mobile operational network capabilities, particularly to network users.

By using the DIS-Java-VRML simulation and modeling toolkit, visualizations of radio-frequency energy and radio path-profiling data can be quickly generated as 3D models. These animated 3D visualizations can be loaded into a networked virtual environment, so that communications planners can detect a variety of problems such as radio frequency interference and gaps in coverage. Planners can also brief senior staff, plan within their own staff, and collaborate with communications staff planners in distant locations using such virtual environments.

DIS-Java-VRML visualization tools can provide a clear picture of the battlespace with respect to the deployed communications architecture. The prototypes presented in this thesis demonstrate the ability to generate a shared visualization that can show a radio communications network in 3D. Such dynamic visualizations increase communications planning information bandwidth and yield more intuitive ways of

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presenting information to users. Higher information density in a more intuitive format enables better understanding with quicker reaction times. This thesis and the visualization tool discussed provide the foundation for fundamental improvements in visualizing radio communications environments.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Computing and Software, Human Systems Interface, Sensors, Modeling and Simulation

KEYWORDS: Virtual Environments, Visual Simulation, Signal Planning, VRML, Java, DIS-Java-VRML, X3D

DESIGN OF A PERSISTENCE SERVER FOR THE RELATIONAL HYPERGRAPH MODEL

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Master of Science in Software Engineering-December 1999

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Second Reader: Douglas Lange, Space and Naval Warfare Systems Center-San Diego

The fundamental purpose of this research is to develop an automated software evolution tool, CASES, for large and complex systems. CASES (Computer-Aided Software Evolution System) is based on the Relational Hypergraph model that is a formal model for describing software evolution processes. This model provides the preliminary mathematical definitions to support the development of CASES. There are five basic functions related to software evolution steps: step refinement, project evaluation, constraint management, personnel management, and step management. There are also five functions related to software evolution components: component management, component traceability, version control and configuration management, dependency management, and inference rule management. CASES is implemented by using Java JDK 1.1.7 and Swing 1.0.3 under the Visual Café version 3.0 environment. The primary contributions of this research include: (1) providing an automated tool for software evolution; (2) validating a software evolution model, the RH model; (3) allowing reuse of software evolution components; (4) describing the software evolution processes; (5) automating the version control of software evolution objects; (6) tracing the software evolution activities; and (7) managing and controlling job scheduling and assignment.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Evolution, Computer-Aided Software Evolution System (CASES)

DEVELOPMENT OF A QUALITY MANAGEMENT METRIC (QMM) MEASURING SOFTWARE PROGRAM MANAGEMENT QUALITY

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The quality of software management in a development program is a major factor in determining the success of a program. The four main areas where a software program manager can affect the outcome of a program are requirements management, estimation/planning management, people management, and risk management. By using current researched practices, interviews with senior program managers, and focus group data, the thesis examines the four areas for practices and structure that a software program manager may implement to positively affect the program. The thesis develops a Quality Management Metric (QMM) to measure the performance of the software manager. The QMM score is determined via a survey consisting of a two-part questionnaire for each of the four main areas examined. The thesis evaluated three software programs for a QMM score. Informal verification and validation of the metric compared the QMM percentile score to an overall program success score for the entire program and yielded positive

THESIS ABSTRACTS

correlation. The establishment of this methodology to quantify the quality of software management is an important step in evaluation of how past and current programs are managed and can serve as a template to improve software management performance in the future.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Management, Requirements Management, Estimation/Planning Management, Risk Management, Quality Management Metric (QMM)

AN EXTENDED KALMAN FILTER FOR QUATERNION-BASED ATTITUDE ESTIMATION

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This thesis develops an extended Kalman filter for real-time estimation of rigid body motion attitude. The filter represents rotations using quaternions rather than Euler angles, which eliminates the long-standing problem of singularities associated with those angles. The process model converts angular rates into quaternion rates, which are in turn integrated to obtain quaternions. Gauss-Newton iteration is utilized to find the quaternion that best relates the values of linear accelerations and earth magnetic field in the body coordinate frame and the earth coordinate frame. The quaternion obtained from the optimization algorithm is used as part of the observations for the Kalman filter. As a result, measurement equations become linear. The computational requirements related to the extended Kalman filter developed using this approach are significantly reduced, making it possible to estimate attitude in real-time. Extensive static and dynamic simulation of the filter using Matlab proved it to be robust. Test cases included the presence of large initial errors as well as high noise levels. In all cases the filter was able to converge and accurately track attitude.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Sensors, Modeling and Simulation

KEYWORDS: Inertial Navigation, Extended Kalman Filter, Quaternion

DEVELOPMENT OF DIGITAL DATA ACQUISITION MODULE AND INTERFACE FOR ANALOG BEARTRAP MISSION DATA

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Master of Science in Computer Science-June 2000

Advisors: Michael K. Shields, M.K. Shields Company

J. Bret Michael, Department of Computer Science

This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into a system residing in a Microsoft Windows NT environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. While current BEARTRAP mission analysis requires a timescale of weeks, this new solution will enable actual tactical use of the data by units at sea. This thesis develops the module and user interface responsible for digital data acquisition of BEARTRAP mission data from multi-track analog sonobuoy tapes as well as a module to access buoy indexing information from the Orion II maritime surveillance software. This work describes the development process as well as the integration and testing of the interface, acquisition, and indexing functionality for the BEARTRAP Post Mission Processing System 2000 (S2K) using Microsoft Visual C++ as the implementation language.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

KEYWORDS: Acoustics, BEARTRAP, DSP, Sound Pressure Level

THESIS ABSTRACTS

RISK ASSESSMENT IN INCREMENTAL SOFTWARE DEVELOPMENT

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Second Reader: CAPT Juan C. Nogueira, USA, Department of Computer Science

Cost overruns, schedule slips, and projects with fewer features or functions than originally specified are some of the difficulties that the software community faces in almost all software projects. The application of proper risk management throughout the lifecycle of the software development can drastically improve the chances of success. Risk management is an essential skill that many good managers possess. Utilizing proper risk management provides early risk detection, which in turn gives the manager more flexibility to mitigate and resolve the risks within the software development project.

This thesis presents a disciplined and systematic risk management tool that can be utilized to assess risk in incremental software development projects from cradle to grave. This methodology can be applied with limited resources, and is adaptable and flexible enough to be used on all software intensive projects. The methodology incorporates the Software Engineering Institute's proven risk taxonomy and questionnaire. It also provides a project manager or project decision-maker an efficient way of assessing risk in incremental software development. Further, this thesis implements the risk assessment framework on a software development project and validates the validity and usefulness as a risk management tool.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Engineering, Risk Management, Systematic Risk Assessment Tool

A SOCKETS APPLICATION PROGRAMMING INTERFACE FOR THE PETITE

AMATEUR NAVAL SATELLITE

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The Petite Amateur Naval Satellite (PANSAT) is an operational communications microsatellite designed at the Naval Postgraduate School (NPS). PANSAT's communications software was intended to be developed after orbital insertion and transmitted to the satellite.

The Sockets Application Programming Interface (API) developed at the University of California, Berkeley is the de facto standard API for network applications. It provides a strong and flexible platform on which to develop a wide variety of programs. It accelerates the development of new applications by providing a standard set of features and isolating the program from the underlying networking mechanisms.

This thesis studied the viability of implementing of a Sockets API for PANSAT based on the Berkeley Sockets. PANSAT's Sockets API was built on BekTek's Spacecraft Operating System (SCOS). Because SCOS source code was not available, network protocols had to be implemented in user mode. SCOS is optimized for multiple small tasks, not the complex processes required for Internet programming. Because of SCOS' limitations in memory management, the development of this protocol stack and API was not successful. SCOS does not have the features required for an implementation like this.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Space Vehicles

KEYWORDS: PANSAT, Internet, TCP/IP, Sockets

THESIS ABSTRACTS

MANAGEMENT OF ORGANIZATIONAL CHANGE: THE CASE OF HUNGARIAN AUTOMATION AND RADAR DEPARTMENT

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Nowadays, military decisionmakers are forced to spend more and more resources on planning and managing organizational change. In order to avoid failure, managers have to diagnose the needs of the organization, to analyze the appropriate method for change and to manage the planned change process. This thesis overviews different approaches and theoretical frameworks applicable to system assessment and diagnoses. The thesis applies the McCaskey model, the organizational system framework, to the case of the Hungarian Institute of Military Technology Automation and Radar Department. It diagnoses the department's status, identifies the gap between the actual and desired status, and it analyses the conducted changes in 1996 and the following years. The thesis concludes with recommendations for improving the management of organizational changes in general.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Assessment, Diagnoses, Management, Organization, Change

AUTOMATED GENERATION OF WRAPPERS FOR INTEROPERABILITY

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Interoperability between software systems is the ability to exchange services from one system to another. In order to exchange services, data and commands are relayed from the service providers to the requesters. Presently, there are some interoperability techniques that aid the exchange of information, ranging from low-level sockets and messaging techniques to more sophisticated middleware technology like object resource brokers. Middleware technology uses higher abstraction than messaging, and can simplify the construction of interoperable applications. It provides a bridge between the service provider and requester by providing standardized mechanisms that handle communication, data exchange and type marshalling. However, the current interoperability techniques, data and services are tightly coupled to a particular server. Furthermore, most developers are trained in developing stand-alone applications rather than distributed applications. This thesis aims at developing a generic interface wrapper that can be used to separate the data and services from the server, and allows the developers to treat distributed data and services as those they are local within an application process space. In addition, the research developed a program to fully automate the process of generating the interface wrapper directly from a specification language such as Prototype System Description Language (PSDL).

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Interoperability with JavaSpace, Jini, Loosely-Coupled Distributed Systems, Prototype System Description Language, Computer Aided Prototype System

THESIS ABSTRACTS

COMMERCIAL-OFF-THE-SHELF (COTS)/LEGACY SYSTEMS INTEGRATION ARCHITECTURAL DESIGN AND ANALYSIS

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Second Reader: Luqi, Department of Computer Science

The nature of COTS products often falls short of achieving the unique requirements of the Department of Defense (DoD). The focus of this thesis is on the use of distributed component middleware technology within the framework of integrating COTS/Legacy system architecture. One of the main problems facing distributed computing is software component integration. There is no single, standardized framework for achieving component integration. However, technologies such as Common Object Request Broker Architecture (CORBA) and Microsoft's Component Object Model (COM) are emerging as solutions to component integration. These methodologies provide a sort of software communications bus for components, supporting platform and language independency. A case study developed within the Navy Integrated Tactical Environmental System I (NITES I) architecture was used to show the integration and communication of COTS/Legacy software components using distributed component technology. This resulted in a distributed object architecture supporting location, platform, and programming language transparencies.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Commercial-off-the-shelf (COTS), Legacy System, Distributed Components, Middleware, Heterogeneous System Integration

STATIC-TASK SCHEDULING INCORPORATING PRECEDENCE CONSTRAINTS AND DEADLINES IN A HETEROGENEOUS-COMPUTING ENVIRONMENT

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Distributed systems have grown in popularity due to the rapid increase in networking of personal computers. A mixture of computers consisting of different architectures can be more powerful, reliable, and scalable than a single supercomputer. The problem of optimally scheduling jobs on a cluster of heterogeneous machines to minimize the time at which the last machine finishes is NP-complete. Nonetheless, the choice of a heuristic algorithm greatly affects the speed of solution. This work evaluates a greedy algorithm, an A* algorithm, and a simulated annealing algorithm applied to the heterogeneous scheduling problem with deadline and dependency constraints. Tradeoffs of speed and schedule quality were noted between the algorithms. The greedy algorithm produced results quicker than the A* and simulated annealing algorithms, but with a lower schedule quality. Because of these offsetting performance criteria, an analysis was conducted to determine which algorithms should be used for which input cases.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Scheduling, Algorithms, Artificial Intelligence, Distributed Computing

THESIS ABSTRACTS

A FORMAL MODEL FOR RISK ASSESSMENT IN SOFTWARE PROJECTS

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The current state of the art techniques of risk assessment rely on checklists and human expertise. This constitutes a weak approach because different people could arrive at different conclusions from the same scenario. The difficulty of estimating the duration of projects applying evolutionary software processes adds intricacy to the risk assessment problem. This thesis introduces a formal method to assess the risk and the duration of software projects automatically, based on measurements that can be obtained early in the development process. The method has been designed according to the characteristics of evolutionary software processes, such as efficiency, requirement volatility and complexity. The formal model based on these three indicators estimates the duration and risk of evolutionary software processes. The approach introduces benefits in two fields: a) automation of risk assessment and, b) early estimation methods for evolutionary software processes.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Risk Assessment, Formal Models, Software Estimation Models, Software Metrics, Project Management

IMPLEMENTATION AND EVALUATION OF A NETWORK ACCESS PROTOCOL

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and

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Traditional Ethernet networks are wired networks. There is now an increasing need, however, for hosts on the network to be mobile without losing network connectivity. This is where wireless technology comes in. The basic idea is to allow a portable device, equipped with an Ethernet transceiver, to relocate while "connected" to the network. Connected here means being within radio range of another transceiver, called an access point, which acts as a relay for the portable device. Its relocation is entirely transparent. Currently, there is a standard that defines how wireless devices communicate within a Local Area Network. This standard is called IEEE 802.11. The standard, however, is not scalable due to the level at which security is handled.

This thesis examines an alternative security solution, the Network Access (NA) Protocol, developed by Associate Professor Dennis Volpano. It runs on mobile devices and designated hosts called bridges and has the potential to scale up to meet the demands of mobility while ensuring secure network access.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Mobile IP, Wireless Computing, IP Mobility Support, IP Encapsulation, IPSec, IPChains, Home Agent, Mobile Host, Foreign Agent, Tunneling, Care-of-Address, MAC, IEEE 802.11, Route Optimization, Intra-Subnet Roaming

THESIS ABSTRACTS

AN AD HOC WIRELESS MOBILE COMMUNICATIONS MODEL FOR SPECIAL OPERATIONS FORCES

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The digitization of the battlefield enables special operators to use improved communications supported by computer networks across a range of missions. The communications paradigm is evolving toward mobile wireless ad hoc networks. This development enables an autonomous system of mobile nodes supporting peer-to-peer communications in forward-deployed military networks. Ad hoc networks have to establish a reliable, secure, instant, and usually temporary, communication infrastructure and to be able to access in a global communications infrastructure.

Our model describes a global communication network supporting the special operator in mobile wireless communications. The main purpose is to provide a handheld wireless communications node which is capable of transferring voice, data, and imagery to and from parallel and vertical command structures within an environment replete with electronic countermeasures. The model will support the representation of requirements such as throughput, quality of service with low power consumption, and low probability of detection/interception. Special Forces are moving toward using commercial-off-the-shelf products and services based on availability and cost effectiveness.

Using GloMoSim tool, simulations for a direct action scenario are ran and the efficiency of on-demand and table-driven routing protocols under different bandwidths and communications loads is compared.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Special Operation Forces, Ad Hoc, Wireless, Mobile Communications, Information Operations, Electromagnetic Pulse Weapons, EMP

DESIGN AND IMPLEMENTATION OF A THREE-TIERED WEB-BASED INVENTORY ORDERING AND TRACKING SYSTEM PROTOTYPE USING CORBA AND JAVA

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Master of Science in Information Technology Management-March 2000

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Many enterprises are still running and maintaining several operating system and platform dependent legacy applications. The variety of platforms and operating systems poses a challenge to system-wide interoperability and performance, increases the cost of maintenance, locks enterprises into certain vendors, and leads to a lack of an adequate information infrastructure which results in a waste of computer resources, manpower, and time. In this thesis, a component-based three-tiered Web-based Inventory Ordering and Tracking System (IOTS) prototype has been designed and implemented that demonstrates the technical feasibility of making an enterprise's applications both interoperable and scalable on a system composed of multiple platforms and different operating systems. The prototype uses CORBA, an industry-backed, non-proprietary, standard-based distributed architecture and Java, a high-level object-oriented language that enables enterprises to leverage the use of the Internet and benefit from the enhancements in the client/server and the decrease in the prices of desktop computers. The prototype demonstrates how to overcome the problem of the stateless nature of HTTP and build the Object Web where Java applets run on the IIOP. The prototype's source code can be tailored to some specific business requirements and enterprises having problems similar to those addressed may benefit from this research and adopt its development methodology.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Other (Interoperability, Re-Engineering, Inventory Ordering and Tracking)

KEYWORDS: Interoperability, Re-Engineering, Inventory Ordering and Tracking, CORBA, Java, Database, Electronic Commerce, Internet, Web-Database Connectivity

INTERNET TELEPHONY

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Wolfgang Baer, Department of Computer Science

During the mid- '90s, data and voice began to merge, propelled by advances in compression technology. The ubiquity of routed Internet Protocol (IP) networks, and the desire to trim telephony costs are the major driving forces of the deployment of Voice over IP (VoIP).

One major advantage of VoIP technologies is that they leverage existing network resources and dramatically reduce, or eliminate telephone costs. If there is an existing Wide Area Network (WAN) then VoIP could be employed over the WAN. However, a WAN link may not be available at each node location. Then only local point of presence (POP) for router based Internet connectivity would be required for VoIP over the Internet. The Internet could be the part of the backbone for the routing of the voice packets.

The advantages of deployment of VoIP are evident. The issue of whether or not to deploy VoIP is more concerned with technical implementation and Quality of Service (QoS) that with a cost-benefit analysis.

This thesis analyzes some of the technical issues surrounding the use of Internet Telephony. Specifically, the Internet Architecture and required QoS for reliable voice, and issues that arise from a dynamic network such as the Internet, and both software and hardware approaches to workstation solution to Internet Telephony.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Internet Telephony, Voice Over Internet Protocol Networks

TRANSPARENT DETECTION OF QOS VIOLATIONS FOR CONTINUOUS APPLICATIONS

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Second Reader: Timothy Levin, Anteon Corporation

Resource Management Systems have the task of determining the structure, resource allocation, and scheduling of applications within their scope. One such system is the Management System for Heterogeneous Networks (MSHN) which uses its Client Library to gather knowledge of its environment. The Client Library is wrapped around each application to gather application status and resource usage information by intercepting and interpreting system calls. In previous work, the Client Library was utilized to provide status of an application at the end of the application's execution. This research focuses on a method to gather QoS information on continuous applications within mission-critical systems, while applications are running rather than after execution, without modification to the application's source code.

The Client Library has been modified to provide application execution information that is evaluated and compared against user-defined specifications. Any QoS violations result in a notification. This is an indicator for MSHN's scheduler to take corrective action such as adapting to use different resources or data formats.

THESIS ABSTRACTS

When wrapped applications are used in conjunction with continuous monitoring, overhead is increased, which may be acceptable if transparent QoS monitoring is essential.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications

KEYWORDS: Quality of Service, Resource Management System, MSHN, Desiderata Wrapper, QoS Violations, Client Library, Resource Monitoring

QOS MANAGEMENT WITH ADAPTIVE ROUTING FOR NEXT GENERATION INTERNET

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Up until today, the Internet only provides best-effort service, where traffic is processed as quickly as possible, with no guarantee as to timeliness or actual delivery. As the Internet developed into a commercial infrastructure, demands for quality of service (QoS) has become apparent. Several QoS service models have been developed to provide and support QoS in the Internet, namely: Integrated Service (IntServ), Differentiated Service (DiffServ) and MultiProtocol Label Switching (MPLS). QoS routing, such as Widest-Shortest Path, Shortest-Widest Path and Shortest-Distance Path, is required in order to support QoS and optimize the resource utilization.

The Server and Agent based Active network Management (SAAM) system is a network management system designed for the next generation Internet. It is capable of supporting all types of service class. It will be able to control and optimize the utilization of the network through resource allocation and adaptive QoS routing.

This thesis describes a design and implementation of the QoS Management component of a SAAM Server. This component optimizes the network resources and supports the various service classes in a cohesive manner, utilizing adaptive routing to balance the network load.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Command, Communications, Control, Computers, and Intelligence)

KEYWORDS: Next Generation Internet, Integrated Service, Differentiated Service, MPLS, Quality of Service, Flows, Networks, Routing

A MAIL FILE ADMINISTRATION TOOL FOR A MULTI-LEVEL HIGH ASSURANCE LAN

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Department of Defense official communications often require special protections to prevent accidental disclosure to unauthorized personnel. A Multilevel High Assurance LAN provides a framework for secure electronic communications, and obviates the need for multiple single level networks. A high assurance trusted computing base (TCB), allows untrusted commercial off-the-shelf (COTS) software, such as an Internet Message Access Protocol (IMAP) server, to run untrusted while access to the file system is mediated by the TCB. Control of creation and deletion of hierarchical structured objects, such as those in the file system, is based on the ability to write to the directory containing the object. For a mail server, this directory structure corresponds to a mailbox hierarchy. The mailbox hierarchy must be designed to allow users to read, create, and send mail at multiple levels. The purpose of this research is to develop a trusted process that automatically creates the mailbox hierarchy for any system user. A Mail File Administration Tool for a Multi-Level High Assurance LAN allows administrators to easily set up IMAP-compatible

THESIS ABSTRACTS

mailboxes for each user. The tool assists in the management of the file structure and enables account administration for multiple LAN users and group accounts at multiple security levels.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Electronic Mail, Multi-Level, High Assurance, IMAP

REFINING A TASK-EXECUTION TIME PREDICTION MODEL FOR USE IN MSHN

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Nowadays, it is common to see the use of a network of machines to distribute the workload and to share information between machines. In these distributed systems, the scheduling of resources to applications may be accomplished by a Resource Management System (RMS).

In order to come up with a good schedule for a set of applications to be distributed among a set of machines, the scheduler within an RMS uses a model to predict the execution time of the applications. A model from a previous thesis was analyzed and refined to estimate the time that the last task will be completed when scheduling several tasks among several machines. The goal of this thesis was to refine the model in such a way that it correctly predicted the execution times of the schedules while doing so in an efficient manner.

The validation of the model demonstrated that it could accurately predict the relative execution time of a communication-intensive, asynchronous application, and of certain compute-intensive, asynchronous applications. However, the level of detail required for this model to predict these execution times is too high, and therefore, inefficient.

DoD KEY TECHNOLOGY AREAS: Computer and Software, Modeling and Simulation

KEYWORDS: Resource Management System, Operating Systems, Distributed Systems, Scheduling

OBJECT SIGNING IN BAMBOO

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The rapid growth in the Internet has been fueled by an exorbitant number of users, organizations and individuals alike, many relying on e-commerce to conduct business including the transport of files. Public Key Infrastructure (PKI) technology has emerged to the forefront as the basis for ensuring secure transactions throughout the Internet. However, this technology is prohibitively expensive for the majority of users. Object signing technology, a subset of PKI technology, provides a veritable means for file transfer ensuring non-repudiation, authentication, and content integrity at an amenable cost.

This thesis provides an introduction to computer security with a specific focus on PKI and object signing technology. It details the selection and implementation of an object signing system layered on Bamboo, namely Pretty Good Privacy (PGP) v2.6.2. Procedures for establishing a Key Server for certificate distribution are also illustrated. It also introduces security pitfalls associated with PKI systems and identifies the security weaknesses of this object signing implementation. For further research, recommendations are provided to improve the overall functionality of this security system and the potential impact any such migration may have on current users.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Object Signing, Public Key Infrastructure, PKI, PGP

THESIS ABSTRACTS

THE APPLICATION OF A VIEWPOINTS FRAMEWORK IN THE DEVELOPMENT OF C4I SYSTEMS

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In the development of large distributed systems, both the detection and resolution of inconsistency in policy, requirements, and specifications pose major challenges. The purpose of this thesis is to examine the inconsistencies in policy, requirements, and specifications in the development of information/Joint Command, Control, Communications, Computers, and Intelligence (C4I) systems. This thesis explores the application of a "viewpoints" framework to aid in the development of distributed information systems.

A viewpoints framework methodology that was developed to aid in the development of distributed systems is the Reference Model of Open Distributed Processing (RM-ODP). This thesis is concerned with the application of the five viewpoints of RM-ODP and the translation of policy into requirements and specifications. In this thesis, the Ballistic Missile Defense (BMD) system is used as a case study to explain how RM-ODP can be used to develop distributed information systems. It was found that identifying inconsistencies regarding interoperability amongst the subsystems of BMD necessitated the use of multiple viewpoints and that firm conclusions could not be made until the system was viewed at the lower levels.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Ballistic Missile Defense, C4I, Interoperability, Policy, Reference Model of Open Distributed Processing, Requirements Engineering, Viewpoints

REQUIREMENTS REUSE IN SUPPORT OF THE AVIATION MISSION PLANNING SYSTEM MIGRATION TO THE JOINT MISSION PLANNING SYSTEM

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Developing correct, complete, consistent and clearly defined requirements is expensive and time-consuming, but is critical to the success of software development. Existing written requirements represent a vast source of domain knowledge that a software analyst can extract for the design of new systems. This thesis describes a modeling process and tool set to identify similar requirements in two requirement documents. The methods developed were tested in a comparison of the Aviation Mission Planning System (AMPS) legacy software and the new Joint Mission Planning System (JMPS). The analysis process creates domain entities, a requirements repository, and statistical matching information for a domain analyst to evaluate reuse potential. Several key tools were automated. The results show that the proposed process and tools significantly shorten the time needed to reuse software requirements.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Requirements Reuse, Keyword Matching, Aviation Mission Planning System, Joint Mission Planning System, Domain Modeling, Domain Analysis

THESIS ABSTRACTS

REPRESENTING TACTICAL LAND NAVIGATION EXPERTISE

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Tactical land navigation is a very important, but extremely difficult task performed daily by small unit leaders. In an effort to find ways to develop expertise more efficiently, a detailed description of expert performance is presented and contrasted with novice and intermediate performance. This definition fits the Recognition Primed Decision model of human cognitive behavior. Then, through use of the Critical Decision Method of knowledge elicitation, interviews with experts at the U. S. Army Special Forces Qualification Course formed the basis of a detailed cognitive model of expert tactical land navigation. Four important characteristics of experts emerge: (1) they rely on high-fidelity mental maps; (2) they blend multiple cues; (3) they adjust and recalibrate tools dynamically; and (4) they visualize spatial information. Finally, a multi-agent system computationally represents the route planning portion of the performance model.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Computing and Software, Human Systems Interface, Ground Vehicles, Modeling and Simulation

KEYWORDS: Agent Based Modeling, Land Navigation, Multi-Agent System, Human Performance Modeling

A PATH-BASED NETWORK POLICY LANGUAGE

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Doctor of Philosophy in Computer Science-September 2000

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Network policies are "traffic regulations" for the networks which make up the Internet. These are necessary for managing the flow of data, for access control to the network, and for managing the network to achieve other types of quality of service goals. However, with the myriad of different policies and networks, all with varying needs, conflicts can arise between network policies. Detecting and correcting these conflicts can be quite difficult for human administrators. Thus, there is a need for a theoretically sound method for specifying policy and for automatically detecting policy conflicts.

This dissertation presents a path-based policy language that is more comprehensive than earlier languages for describing network policy. The Path-Based Policy Language (PPL) is a formal language for constructing models of Internet service and access control. This path-based language is extensible and allows for an unambiguous representation of network policies based on both the static and dynamic attributes of today's networks. To support this language, both a compiler and policy conflict tester were developed. These tools accept network policies specified in PPL, translate them into formal logic, and using a theorem prover to test for policy conflicts. PPL allows for the efficient representation of large networks with its abbreviated path format. This path format allows multiple paths to be represented with one statement.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Policy Language, Path-Based, Network Management, Conflict Detection, Conflict Resolution

THESIS ABSTRACTS

AUTHENTICATION IN SAAM ROUTERS

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Server and Agent based Active network Management (SAAM) is a network protocol developed at the Naval Postgraduate School to address the router software requirements for the Next Generation Internet (NGI). A working prototype has existed for over nine months to materialize abstract research ideas in the field of active networking.

Authentication is particularly important because SAAM uses mobile code, called resident agents. These resident agents are loaded onto SAAM routers dynamically, and execute on the destination SAAM router. Mobile code in the SAAM system requires an authentication scheme to prevent an outsider from sending a malicious resident agent. Two issues explored are time synchronization and authentication. This thesis focuses on authentication.

With authentication, SAAM can be used as the technical network infrastructure to support Network Centric Warfare (NCW) as described in JV2010. The NCW network must allow mobile code to securely execute on the fly. The prototype developed in the thesis authenticates new nodes that join a SAAM network using Kerberos. Signaling data, also called control traffic, is certified with a dynamic signature key that changes every two minutes. Once a SAAM node is authenticated, its identity is protected throughout the battle. In the same way that Allied forces use Identification Friend or Foe (IFF) traffic today, SAAM authentication could support NCW. The NCW network must also be self-healing. Autoconfiguration is already integrated into the SAAM prototype. Network failures are detected within 500ms. Probing agents are also deployed to investigate suspicious activity within the network. Future probes could fingerprint a specific group of hackers while on-line, using genetic algorithms.

The effects of SAAM on the organizational behavior of a tactical Information Warfare (IW) organization are explored in this thesis.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Authentication, Encryption, Routing, Java, Key Distribution, Kerberos, Secure Time Synchronization

DESIGN AND IMPLEMENTATION OF A PLATFORM INDEPENDENT PROTOTYPE SPECIFICATION EDITOR

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Master of Science in Computer Science-September 2000

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Second Reader: C. Thomas Wu, Department of Computer Science

The Computer Aided Prototyping System (CAPS) developed by the Computer Science Department, Naval Postgraduate School, is an integrated set of tools that is used for rapid prototyping of real time systems. The PSDL editor, a key component of CAPS, allows users to specify prototype design graphically through data flow diagrams and data flow component property menus, and automatically translates the graphical objects into textual specification written in the Prototype System Description Language (PSDL).

This thesis builds upon the previous work done on the CAPS editor design and develops an improved Java based graphic/text editor for the PSDL. New functionality is added to increase the user friendliness of the editor and maintain design consistency in real time. The new enhanced editor provides undo/redo and other essential editing functionality, automatic completion of stream types, as well as automatic checking and propagation of the timing constraints.

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The new editor is more powerful than ever. It tested successfully in classroom to generate prototype and has been used as a tool for software engineering graduate students to design their computer aided prototype project.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer-Aided Rapid Prototyping, Software Specification, Real Time System, Graphic Editor, Java

TOWARD AN OBJECT-ORIENTED ARCHITECTURE FOR THE ENHANCED MULTI-SEGMENT TRACKER (EMST)

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This work is part of an ongoing effort to integrate the separate BEARTRAP post-mission analysis tools into an application operating in a Microsoft Windows environment. The new integrated system will replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis is the initial effort toward reengineering the Enhanced Multi-Segment Tracker (EMST) module to incorporate object-oriented capabilities and architecture. The module is an algorithm implemented in the C++ programming language for reconstructing a submarine's track through the water based on analysis of collected magnetic and acoustic data.

The first step requires reverse engineering the existing source code in order to understand the module. The hypothesis is that by reverse engineering the EMST source code, the attributes, behaviors and relationships that characterize the system can be identified, which will enable the future construction of objects for reengineering the system into an object-oriented architecture. The thesis describes the reverse engineering tasks performed on the existing EMST source code and presents methods for determining the attributes, behaviors and relationships that characterize the algorithm.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Engineering, Software Reverse Engineering, Software Re-Engineering, Object-Oriented Technology, Unified Modeling Language, BEARTRAP

INTEROPERABILITY AND SECURITY SUPPORT FOR HETEROGENEOUS COTS/GOTS/LEGACY COMPONENT-BASED ARCHITECTURE

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There is a need for Commercial-off-the-shelf (COTS), Government-off-the-shelf (GOTS) and legacy components to interoperate in a secure distributed computing environment in order to facilitate the development of evolving applications.

This thesis researches existing open standards solutions to the distributed component integration problem and proposes an application framework that supports application wrappers and a uniform security policy external to the components. This application framework adopts an Object Request Broker (ORB) standard based on Microsoft Distributed Component Object Model (DCOM). Application wrapper

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architectures are used to make components conform to the ORB standard. The application framework is shown to operate in a common network architecture.

A portion of the Naval Integrated Tactical Environmental System I (NITES I) is used as a case study to demonstrate the utility of this distributed component integration methodology (DCIM).

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: COTS, GOTS, Application Wrapper, Security Model, Network Architecture, Component Interface, Open Standards

RE-TARGETING THE GRAZE PERFORMANCE DEBUGGING TOOL FOR JAVA THREADS AND ANALYZING THE RE-TARGETING TO AUTOMATICALLY PARALLELIZED (FORTRAN) CODE

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This research focuses on the design of a language-independent concept, Glimpse, for performance debugging of multi-threaded programs. This research extends previous work on Graze, a tool designed and implemented for performance debugging of C++ programs. Not only is Glimpse easily portable among different programming languages, (i) it is useful in many different paradigms ranging from few long-lived threads to many short-lived threads; and (ii) it generalizes the concept of intervals over Graze's original definition. Glimpse's portability has been validated by demonstrating its usefulness in performance debugging of both Java programs as well as automatically parallelized FORTRAN programs.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Performance Debugging, Java Threads, Automatically Parallelized FORTRAN Applications

COMMUNICATION MODELS IN MOBILE COMPUTING SYSTEMS AND MOBILE AGENTS

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Master of Science in Computer Science-March 2000

Advisor: J. Bret Michael, Department of Computer Science

Second Reader: Gilbert M. Lundy, Department of Computer Science

This thesis study covers wired and wireless mobile computing environments, introduces the components of the mobile environment, discusses the constraints of mobility, and contains a taxonomy of the current techniques/models that reduce the overheads associated with wireless mobile communication. One of the goals of this thesis study was to identify and define communication techniques and models that are used by mobile computing systems to minimize wireless communication cost. The following communication techniques and models have been covered in this study: caching, screen caching, differencing, protocol reduction, header reduction, data access profile, delayed writes, strict and loose reads, semantic callbacks and validators, data allocation, data compression, data scheduling, proxy process, adaptation strategy, resource revocation, auto connect/disconnect, and adaptive antennas. The trade-offs between these techniques/models have also been presented. Other goals of this study were to introduce scripts and mobile agents, and explore their security features in mobile computing environments. The usage of mobile agents in military applications has been investigated. Finally, conclusions and recommendations have been provided for wireless mobile computing and mobile agent technology.

DoD KEY TECHNOLOGY AREA: Computing and Software

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KEYWORDS: Mobile Computing, Portable Computers, Mobile Environments, Mobile Agents, Intelligent Agents, Wireless Networks, Caching, Proxy Process, Adaptation, Mobile Communication, Wireless Communication, Disconnected Operation, Energy Consumption, Cellular Communication

ANALYSIS FOR A TRUSTED COMPUTING BASE EXTENTION PROTOTYPE BOARD

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Master of Science in Electrical Engineering-March 2000

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Agencies, institutions, individuals are demanding the use of commercial-off-the-shelf (COTS) systems and cannot enforce mandatory security policies with these systems, which are equipped only with discretionary access controls. An inexpensive implementation of a multi-level secure local area network utilizing commercial-off-the-shelf hardware and software does not exist.

The Naval Postgraduate School (NPS) is developing a Multi-level Secure Local Area Network (MLS LAN) to provide secure information sharing, classified at different security levels. The MLS LAN extends the high assurance of an evaluated multi-level secure system to a LAN that is formed by commercial personal computers (PCs) running commercial operating systems and office productivity software. The MLS LAN accomplishes the defined functionality by using custom boards which are designed to be plugged into personal computers. The boards are named the Trusted Computing Base Extension (TCBE). The TCBE is intended to provide trusted path and object reuse supporting services to the network TCB.

This thesis describes the hardware and software components, structures, interfaces required for the TCBE to complete a trusted path and control the client PC. Potential implementations are suggested and analyzed for security implications. A preliminary TCBE prototype has been constructed and tested for selected TCBE functions. It is shown that the TCBE prototype can be made both non-by-passable and tamper resistant.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics

KEYWORDS: Multi-level Security, Trusted Path, High-Assurance, Network Client

AN ANALYSES OF INTERNET/INTRANET INFORMATION SYSTEM ARCHITECTURES WITH ORACLE 8i FOR TURKISH NAVY

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Master of Science in Information Technology Management-March 2000

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Turkish Navy has made a strategic commitment to Oracle DBMS, by making an enterprise contract with Oracle Corporation, which places Oracle DBMS at the heart of all information processing in Turkish Navy. Ten years later currently established Oracle DBMS based information systems will be legacy systems and Turkish Navy will be bound to under Oracle proprietary lock-in, unless careful approach in deploying these new systems is not made.

Oracle 8i is the latest version of the Oracle Corporation's DBMS can be solution to this problem. With Oracle 8i's Java-enabling components-Object Request Broker (ORB), Java Virtual Machine (JVM), and embedded JDBC Driver- Turkish Navy have a wealth of technologies at its disposal. Turkish Navy has a choice of several programming models - PL/SQL, JDBC, SQLJ, CORBA, and EJB; and a choice of

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protocols - Net8 and CORBA-IIOP. Selecting model over another can be a daunting and very important task. Each model has strengths and weaknesses for a particular task.

This research surveys Oracle Java Platform and researches different development architectures with their pros and cons, and points out the direction that should be taken in order to ensure scalability, maintainability, interoperability and extensibility of the future systems which will prevent the proprietary lock-in of the certain vendors and their products.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Information System Management)

KEYWORDS: Oracle, Oracle 8i, Enterprise Java Beans, CORBA, Information System Architectures, Microsoft vs. Oracle, Turkish Navy, EJB, Java, PL/SQL

A MODEL FOR GENERATION AND PROCESSING OF LINK STATE INFORMATION IN SAAM ARCHITECTURE

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Gilbert M. Lundy, Department of Computer Science

This thesis presents a model of link state advertisement generation for the SAAM (Server and Agent Based Network Management) architecture. The model includes generation and processing of link state data. In a SAAM network, a central server manages a region of 20-40 lightweight routers. The server learns the link performance of the routers from processing Link State Advertisement messages that are periodically sent by the routers. The server uses the information to maintain a Path Information Base to manage routing within the region. A router also sends a triggered Link State Advertisement message when one of its interfaces fails.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Quality of Service, Networks, Flows, Link State Advertisement

APPLICATION OF FAULT-TOLERANT COMPUTING FOR SPACECRAFT USING COMMERCIAL-OFF-THE-SHELF MICROPROCESSORS

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Low availability, high cost, and poor performance of radiation hardened (rad-hard) equipment has driven the market to rely on commercial-off-the-shelf (COTS) equipment for the computing needs of today's spacecraft. This thesis describes the tailoring of a COTS embedded real-time operating system and design of a human-computer interface (HCI) for a triple modular redundant (TMR) fault-tolerant microprocessor for use in space-based applications. One disadvantage of using COTS hardware components is its susceptibility to the radiation effects present in the space environment, and specifically, radiation-induced single-event upsets (SEUs). In the event of an SEU, a fault-tolerant system can mitigate the effects of the upset and continue to process from the last known correct system state. The TMR basic hardware design used for this research is an acceptable fault-tolerant design candidate for the main processor for space-based applications. We found that a COTS embedded real-time operating system could be tailored to

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support the TMR hardware. The HCI accepts serial data from the TMR, correctly identifies the source of the error, allows for processor mode selection and provides system- and board-level reset capabilities. The tailored operating system combined with the HCI is a viable software implementation to support hardware-based fault-tolerant computing in a space environment.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Space Vehicles, Human System Interface

KEYWORDS: Fault Tolerance, Embedded Operating System, Human Computer Interface, Triple Modular Redundant Hardware, Spacecraft Design

THE SHARP EVOLUTION: DEVELOPMENT OF THE SIERRA HOTEL AVIATION REPORTING PROGRAM FROM THE DECK PLATES

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Due to constant changes in the military environment, operations tempo, resource limitations, and leadership directives, the fashion in which the military computes its training and readiness is constantly in flux. Previous readiness calculations were accomplished from simple two-dimensional models of qualifications by dates. With the increase of more sophisticated requirements, a new six-dimensional model of training and readiness was invented to compute and even predict future readiness levels, for aviation as outlined in the Training and Readiness (T&R) Manual CNAP INST/CNAL INST 3500 Series.

Due to the complex requirements of the new T&R Manual, a software tool was required to track post-flight data and compute aviation combat readiness. The T&R Manual is revised at irregular intervals by independent type wings, resulting in a constant requirement to re-develop existing readiness models and tracking programs. To fulfill this requirement, a team of Naval Aviators with a combination of software engineering expertise, military operations, and project management experience was created to develop a modular based rapid prototype application.

This thesis will review the unique software development models utilized in rapid military application development, contrasting with existing application development models, and the utilization of non-traditional techniques to meet defense readiness requirements. This thesis will also review other readiness tracking systems to compare and contrast the ability to meet the diverse needs of fleet readiness models through efficient software development.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Manpower, Personnel, and Training

KEYWORDS: Software Engineering, Combat Readiness, Software Management, COTS, Software Evolution Model

A TRUSTED CONNECTION FRAMEWORK FOR MULTILEVEL SECURE LOCAL AREA NETWORKS

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Second Reader: Timothy Levin, Anteon Corporation

The Naval Postgraduate School is developing a Multilevel Secure Local Area Network (MLS LAN) that incorporates commercial-off-the-shelf client workstations to provide multiple users with simultaneous secure access to stored data of different sensitivity levels. The MLS LAN uses a Trusted Computing Base Extension (TCBE) in the LAN's client workstations to extend the TCB from the trusted server across the

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network to these workstations. Connections between elements of the LAN are under TCB control and are conducted by way of several new communications protocols.

Using a realistic System Requirements Document and a High Level Protocol Analysis, this thesis presents a framework of communications protocols that will enable the components of the MLS LAN to securely interact. The framework first presents a communications channel protocol that protects all data transmitted on the network. Following this, three other protocols are described that enable MLS LAN users to safely login and negotiate a secure session, access Application Protocol Servers that provide services such as e-mail or WWW services, and to use typical LAN-based office automation services. Finally presented is an analysis of both TLS and IPSec, which provides evidence that IPSec is best suited to provide MLS LAN communications protection.

DoD KEY TECHNOLOGY AREA: Other (Computing and Networks)

KEYWORDS: Multilevel Security, Trusted Path, High-Assurance, Network Client-Server

HELICOPTER URBAN NAVIGATION TRAINING USING VIRTUAL ENVIRONMENTS

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Second Reader: Barry Peterson, Department of Computer Science

Helicopter missions are never defined as "...successful navigation to and return from a location." Navigation, in and of itself, is not the mission – it is, however, a skill that all helicopter pilots are expected to master in order to function as pilots. *Navigation is a means to an end.*

Helicopter operations, being inherently expensive and unforgiving of mistakes, are prime candidates for such innovative training techniques as virtual (3-D) fly-throughs. This thesis, as a logical extension of previous research, seeks out ways to enhance current training methods for urban helicopter navigation using state-of-the-art-technology. Using empirical data from pilot surveys and controlled experiments, principles can be formulated to determine the level of computer graphics fidelity necessary for helicopter crews to conduct a virtual flight in an urban setting that is a credible, effective tool in preparation of an actual flight.

This research does not seek a replacement method of training helicopter terrain navigation – pilots must still be taught the fundamental skills of map interpretation and terrain association using conventional training techniques. However, it is the intent of this research to explore methods of enhancing and supplementing site-specific helicopter navigation training through the transfer of spatial knowledge from the virtual world to real-world applications.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Manpower, Personnel, and Training, Modeling and Simulation

KEYWORDS: Helicopter, Urban Terrain, Virtual Environments, Navigation Training, Mission Rehearsal, Spatial Orientation, Situational Awareness

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IMPLEMENTATION AND EVALUATION OF A NETWORK ACCESS PROTOCOL

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and

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Second Reader: J. Bret Michael, Department of Computer Science

Traditional Ethernet networks are wired networks. There is now an increasing need, however, for hosts on the network to be mobile without losing network connectivity. This is where wireless technology comes in. The basic idea is to allow a portable device, equipped with an Ethernet transceiver, to relocate while "connected" to the network. Connected here means being within radio range of another transceiver, called an access point, which acts as a relay for the portable device. Its relocation is entirely transparent.

Currently, there is a standard that defines how wireless devices communicate within a Local Area Network. This standard is called IEEE 802.11. The standard, however, is not scalable due to the level at which security is handled.

This thesis examines an alternative security solution, the Network Access (NA) Protocol, developed by Professor Dennis Volpano. It runs on mobile devices and designated hosts called bridges and has the potential to scale up to meet the demands of mobility while ensuring secure network access.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Mobile IP, Wireless Computing, IP Mobility Support, IP Encapsulation, IpSec, IPChains, Home Agent, Mobile Host, Foreign Agent, Tunneling, Care-of-Address, MAC, IEEE 802.11, Route Optimization, Intra-Subnet Roaming

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